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A MONTHLY SUMMARY OF BUSINESS AND ECONOMIC CONDITIONS IN TEXAS

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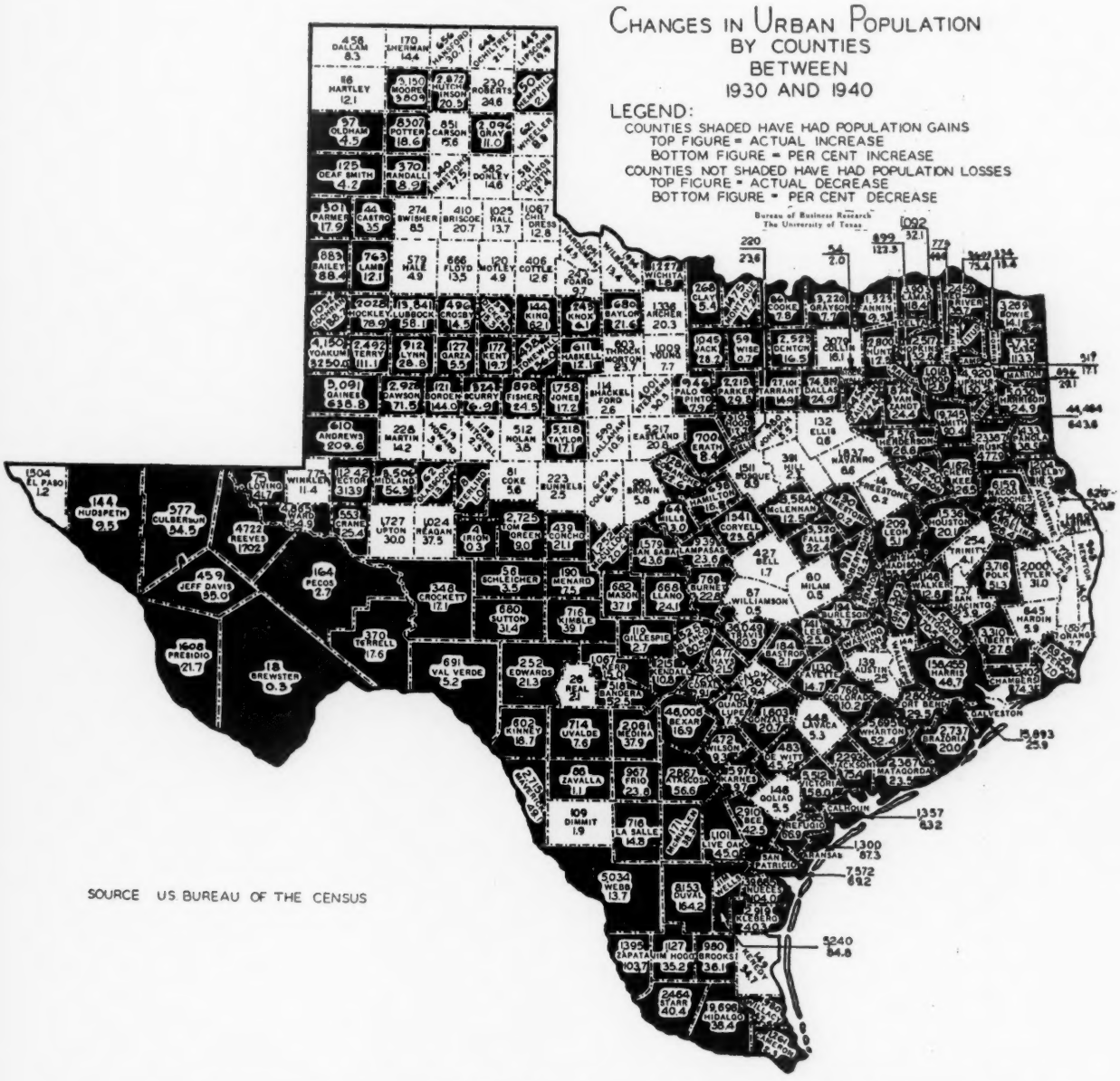
CHANGES IN URBAN POPULATION
BY COUNTIES
BETWEEN
1930 AND 1940
LEGEND:
COUNTIES SHADED HAVE HAD POPULATION GAINS
TOP FIGURE = ACTUAL INCREASE
BOTTOM FIGURE = PER CENT INCREASE
COUNTIES NOT SHADED HAVE HAD POPULATION LOSSES
TOP FIGURE = ACTUAL DECREASE
BOTTOM FIGURE = PER CENT DECREASE
Bureau of Business Research
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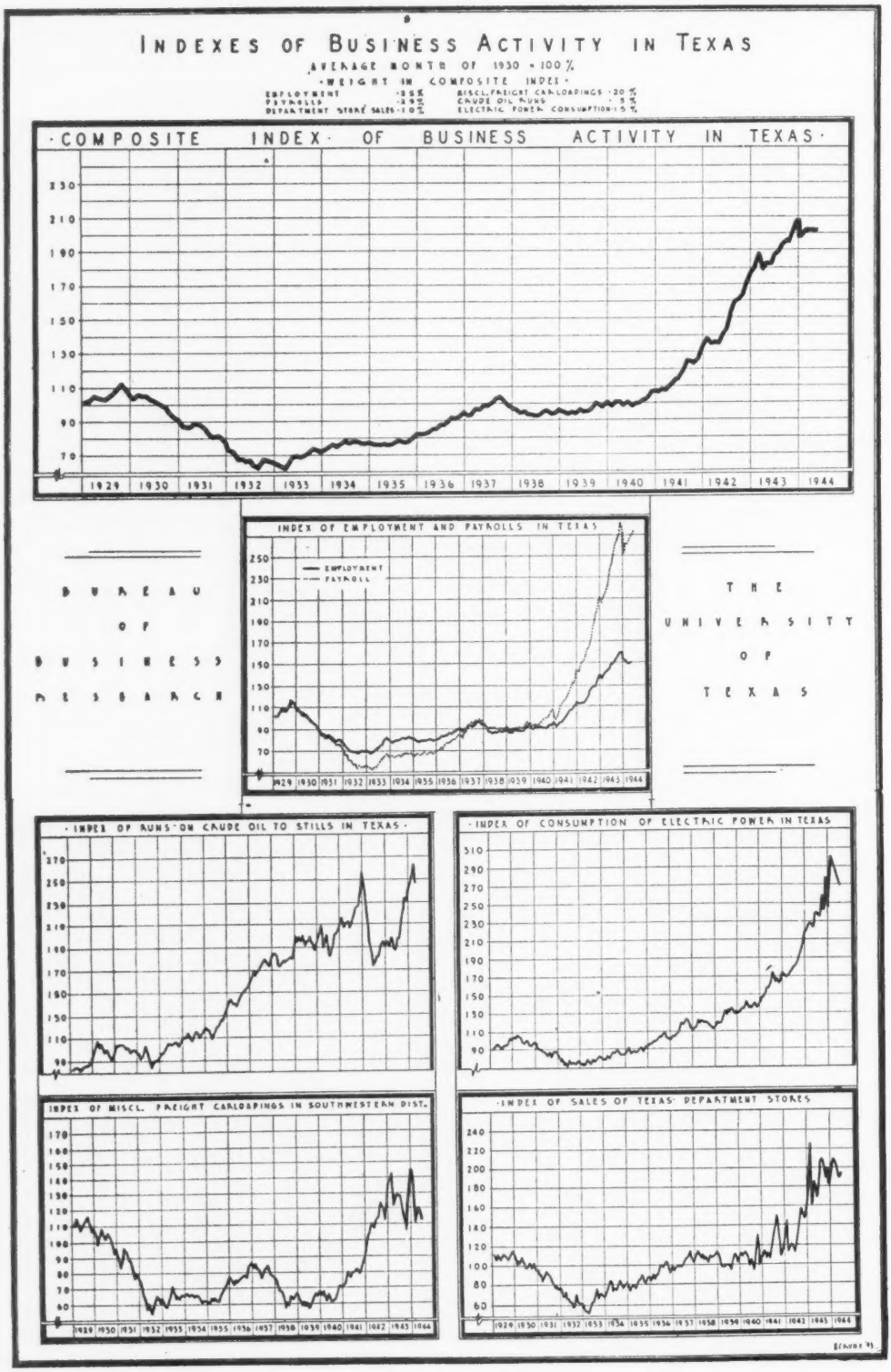
INDEXES OF BUSINESS ACTIVITY IN TEXAS
AVERAGE MONTH OF 1930 = 100%
WEIGHT IN COMPOSITE INDEX
EMPLOYMENT 35%
PAYROLLS 35%
DEPARTMENT STORE SALES 10%
MISCL. FREIGHT CARLOADINGS 20%
CRUDE OIL RUNS 5%
ELECTRIC POWER CONSUMPTION 5%
COMPOSITE INDEX OF BUSINESS ACTIVITY IN TEXAS
INDEX OF EMPLOYMENT AND PAYROLLS IN TEXAS
EMPLOYMENT
PAYROLL
BUREAU OF BUSINESS RESEARCH
THE UNIVERSITY OF TEXAS
INDEX OF RUNS-ON CRUDE OIL TO STILLS IN TEXAS
INDEX OF CONSUMPTION OF ELECTRIC POWER IN TEXAS
INDEX OF MISCL. FREIGHT CARLOADINGS IN SOUTHWESTERN DIST.
INDEX OF SALES OF TEXAS DEPARTMENT STORES

Business Review and Prospect

TEXAS BUSINESS REVIEW

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In the order of urgency the major problems before the Nation today are: first, the concentration of our military and economic power for the defeat of Japan; second, the establishment of an international organization, political and economic, designed to insure future peace and improve living standards the world over; and third, the reconversion of industry for peace-time production as rapidly as possible after the military requirements both as to men and materials have been fully met. The main emphasis during coming months will properly continue to be placed upon the solution of the first two problems; but in the background, and less conspiciously, the solution of the third problem will command increasing attention as the war draws to a successful conclusion and the framework for future international relations is completed.

It has been well stated that "in historical perspective the reconversion period will not be long, but its importance will be great; for in it a turn may be made either toward, or away from, the perpetuation and extension of detailed government controls over business. The decisions made will not only affect the volume of business activity and employment; they will also exert a lasting and profound influence upon the nature of our economic system in years to come."

In a comprehensive report released to the press recently, Chairman Krug of the War Production Board expresses confidence in free enterprise and rejects the idea that government planning in the sense of control by blueprint, can be as effective as private planning. Like its predecessors in 1944—the Baruch-Hancock report and the third annual report of the Truman committee—the Krug report takes its stand on the simple ground that government regulations, administration, and control would impede and slow up the reconversion process and diminish employment and production. The keynote is the declaration that "it is necessary to get rid of regulations and production limitations as quickly as possible. They automatically put ceilings on initiative, imagination, and resourcefulness; the very qualities the country will need most if we are to have a resilent and rapidly expanding economy after the defeat of Japan."

Reconversion in Texas and the Southwest

Considerable attention is now being given to problems relating to post-war employment in Texas and the Southwest. What will be the supply of labor and the demand for labor in the scores of local areas throughout the State and Region? These are questions for which answers are being sought—not in terms of the economic situation which prevails under war conditions, but those which may be expected and desired under a peace economy. Possibilities for full post-war employment in Texas and the Southwest are quite favorable. First, are the established industries trades and service occupations which will experience active operations for many years; and second, are the possibilities for new industries. The latter possibilities have been outlined by Mr. Johnson in a series of articles in the Review to which the reader is referred. The extent to which the potentialities for development of new industries are actually realized will determine in large measure the amount, profitableness of employment, and general prosperity of this State and Region in terms of decades and not merely in terms of a few years.

It is obvious that the first avenues to be opened up for post-war employment are the industries, trade, and service occupations already established and such new ones or extensions as are clearly visible on the basis of completed or well advanced plans. On this basis of established industries alone, the outlook for employment possibilities in this State and Region during the next few years is in the main highly favorable, and no serious unemployment on a wide scale or of long duration is expected in Texas and the Southwest immediately after the defeat of Japan. The following are among the reasons which may be cited for this favorable expectation:

1. Industries in the Southwest region which were going concerns before the outbreak of the war had relatively simple problems in converting from civilian to war production. This situation was possible because the major portion of Texas industry was engaged in oil refining, in processing of farm products, in manufacturing equipment for the oil industry, in producing heavy chemicals, in fabricating canvas goods, and in manufacturing garments including work clothes.

2. So familiar with the processes involved were the industrial managers of these plants that they were able not only to transform their own plants but also, with Government assistance, to guide the work of numerous subcontractors, many of whom had no previous experience with the specific product they undertook to make.

3. As a result of the foregoing situation it is expected that these industries will reconvert to civilian production with little difficulty once labor and materials become readily available.

On the other side of the picture the following facts should be noted:

1. Industries born of the war, without background of production for the civilian market and in many cases

sponsored and financed by the Government, face a difficult outlook. In the latter group the most important in this Region are those engaged in aircraft, shipbuilding, and ordnance production. It is expected that as soon as the war with Japan ends these industries will contract to where they will constitute but a small proportion of their present magnitude. Thus the main problem is to find employment for the large numbers of workers released from war production and to find ways of utilizing these plants for some type of civilian activity.

2. Perhaps the greatest post-war problem in this Region is to determine what to do with the numerous small plants that came into existence with the war and had had no pre-war experience in production for the civilian market. This is a problem to which the Smaller War Plants Corporation is giving a great deal of attention and about which officials of the S. W. P. C. are not altogether optimistic.

When the composition of the working forces in these war plants is considered, however, the situation looks far less serious. Employees in these plants consist to a large extent of housewives, children, older men, rural residents in the surrounding areas and employees in service occupations who entered war plants from nearby communities because of the higher pay. A large proportion of these people will return to their normal activities as the need for workers in war plants diminishes.

Current Business Activity in Texas

Retail dollar sales in Texas continue to show favorable year to year comparisons in spite of the high level of sales which prevailed a year ago and the difficulty of obtaining sufficient stocks of many lines of merchandise. Total sales of 982 reporting establishments showed an increase of 4.2% over May, 1944, and the aggregate sales for these stores during the first five months were 9.9% over those of the corresponding period a year ago.

Among the lines of retail trade that made the most favorable showing in the current year compared with May last year were: lumber and building materials, up 32.0% over the month of May, 1944, and more than 31% over the year to date in 1944; hardware sales up 11.6% and 15.1% respectively for the two periods; farm implement dealers sales up 11.0% and and 15.1%; dry goods and general merchandise 8.3% and 15.3%; and drug stores sales 8.0% and 7.7%. Lines of merchandise showing substantial declines were: motor vehicle down 22.7% from May, 1944, and 10.6% from the year to date in 1944; women's specialty shops 16.0% and 17.5% respectively; while sales of men's and boy's clothing stores declined 5.2% from May last year but were still 2.2% above 1944 for the year to date period. Indications are that the favorable year to year comparisons noted in retail sales will be maintained if goods are available to meet the demand.

Other favorable business indicators are: building permits, the aggregate of which for 40 cities during May was more than double that of a year ago; postal receipts, up 8% from May, 1944; and electrical power consumption showed an overall gain of 11.9%. Commercial power consumption gained 12.4%; industrial 14.4%; and residential 14.3%.

Texas oil production is still mounting. Average daily production for the State during May was 2,176,150 barrels, a gain of 9%, over May, 1944, and represented nearly 45% of the total average daily production for the entire Nation.

Texas Agriculture

A Texas wheat crop estimated at 75,420,040 bushels by the United States Department of Agriculture on April 1 was revised downward to 56,562,000 bushels in the May 1 report and to 36,200,000 bushels in the June 1 report. Actual production of wheat in this state in 1944 was 74,746,000. The indicated yield is 8.0 bushels per acre on the acreage standing May 1, compared with a final yield of 19.0 bushels per acre last year and an average of 10.1 bushels per acre for the period 1934–1943. The indicated oat crop of 43,912,000 is well above both the 38,600,000 bushel crop of last year and the ten-year average of 33,425,000 bushels.

Weather conditions continued unfavorable through May. Dry weather in western areas not only greatly reduced the wheat crop but also delayed planting of sorghums and cotton. The excessive moisture condition which prevailed in north-central and eastern portions of the State during the early spring months was improved sufficiently during May to allow farmers to do much needed field work.

The condition of Texas range feeds and pastures according to the report of the U. S. Department of Agriculture, declined sharply during May as droughty conditions assumed serious proportions in many counties in the western half of the State. Average condition for the State was reported at 81% on June 1, compared with 88% a month earlier and 86% for the 20-year average for June. Rainfall during the month was below normal in all districts; ranges were particularly dry and range feeds short in the northwestern and western parts of the State, where earlier deficiencies had developed. Pasture and range feed conditions continued good in central and eastern districts although rains were needed rather generally to insure summer grazing and to replenish depleted surface moisture. A few local scattered rains in early June were beneficial and more general rains occurred during the middle of the month.

Cattle showed some loss in condition during May in dry western areas but still were in fair to good flesh. Cattle in other areas continued in very good condition. Good calf crops were reported generally and losses have been light. The condition of cattle as of June 1 was reported at 84%, a two-point loss from a month earlier and also two points below the 20-year average for June.

Sheep and lambs continued in good shape, according to the Department report, although showing a significant decline from the splendid condition of May 1, with drying feed particularly affecting the progress of lambs.

Texas Farm Cash Income

Agricultural cash income in Texas during May totalled $91 million compared with $83 million during the corresponding month last year, or an increase of nearly 10%. Aggregate farm cash income for the first five months of the year amounted to $381 million compared

with $328 during the corresponding period in 1944, or an increase of more than 16%. Most of the gain in the cash income during May was derived from cattle with sheep and calves contributing to the increase but only to a minor extent. Cattle marketings were substantially, and prices were moderately, higher than during May, 1944.

INDEXES OF AGRICULTURAL CASH INCOME IN TEXAS

(Average Month 1928–32=100)

Districts	May, 1945	April, 1945	May, 1944	Cummulative Cash Income in Thousands of Dollars Jan.-May Inclusive 1945	1944
1–N	273.8	305.1	144.9	40,077	21,624
1–S	484.1	380.6	465.6	36,282	31,735
2	249.4	217.3	220.9	38,413	24,589
3	301.2	171.1	266.8	16,160	13,127
4	214.3	228.7	252.3	43,232	41,086
5	214.5	194.2	229.3	13,526	12,430
6	262.2	304.1	247.2	18,545	15,900
7	262.1	212.4	211.2	28,474	22,644
8	254.3	291.4	315.4	30,514	32,353
9	257.5	195.4	242.2	26,887	27,078
10	126.2	167.8	70.4	19,001	15,047
10–A	1078.1	770.5	977.2	70,324	70,645
STATE	300.5	278.2	274.5	381,435	328,258

NOTE: Farm cash income as computed by the Bureau understates actual farm cash income by from six to ten per cent. This situation results from the fact that means of securing complete local marketings, especially by truck, have not yet been fully developed. In addition, means have not yet been developed for computing cash income from all agricultural specialties of local importance in scattered areas throughout the State. This situation, however, does not impair the accuracy of the *indexes* to any appreciable extent.

The State index of farm cash income as a percentage of the average monthly income for the 60 months 1928–32, adjusted for seasonal variation, was 300 which was well above both the preceding month and the corresponding month last year, as indicated in the following table with variations in the district indexes to be noted.

With the prospective sharp decline in wheat marketings during the new marketing season as compared with last year, and with little prospect of a significant rise in wheat prices during the next three months when most of the wheat will be marketed, the farm cash income from wheat will not amount to more than half of the record income from this source in 1944. Prospects for cash income from crops other than wheat, moreover, are not such at the present time to warrant optimism that the decline in wheat income will be compensated for by gains in other crops. Unless prices for farm products maintain a fairly wide margin of gain over a year ago, the increase in income for the year to date may not be fully maintained. This margin could in fact be completely wiped out if other crops yet to be harvested made as poor relative showing as wheat.

F. A. BUECHEL.

Prices for 1945 Cotton Crop

In the May issue of the REVIEW I gave the known facts about prospects for production and prices for the 1945 cotton crop for Texas. During the past month reports indicate some deterioration in production prospects as a result of unfavorable weather and labor shortage.

Up to this time no official announcement has been made, but it is definite that the Government, through the Commodity Credit Corporation, will inaugurate a buying program for the 1945 cotton crop at parity, and it is fairly certain that parity price for M. 15/16 at Memphis will be figured at approximately 22.70 cents a pound with deductions or additions due to relative freight distances from Carolina Group B mill points.

Two plans are being considered for operation of the buying program. The simplest one is the one in which the Government would merely announce a date after which it would buy through the C. C. C. farmers' cotton at parity plus or minus grade and staple premiums above or below M. 15/16. The date set would be some time in the spring of 1946, to enable cotton to stay as long as possible in private hands, to facilitate trade and prevent gluts in warehouses.

The second plan would begin the Government buying program on August 1 at about 22.15 for M. 15/16 Memphis, and other grades and staples at official differences yet to be established, and increase the purchase price 5 points per month thereafter until it reached 22.70 cents for M. 15/16 Memphis.

Whichever purchase program or modification is adopted, the farmers are assured full parity price for their cotton, though in either case the farmers will have to pay the carrying costs until the spring.

It needs to be emphasized also that the purchase program, regardless of how it is done, will in no way interfere with the farmer's right to a Government loan of 92½ per cent of parity price on his cotton, or about 21 cents for M. 15/16 at Memphis with deductions or additions due to relative freight distances from Carolina Group B mill points.

It is also possible that arrangements will be made by the C. C. C. whereby local banks may participate in financing the harvested crop, probably through some form of agency contract.

A. B. COX.

Summary of the Rise of the Plastics Industries

The field of synthetics, of which plastics is an important part, represents one of the most important and most progressive branches of the world's chemical industry of today.

The entire realm of synthetics has, of course, been greatly stimulated by the exigencies of World War II; the resulting expansion of the several branches constituting this highly significant phase of modern industry has been little short of phenomenal. The history of synthetics is one of constantly broadening fields of application, associated with the continual development of new synthetics and, for many of them, the constant improvement by which they are adapted to new uses or are rendered more suitable to older uses.

Back of the accelerated production and the correspondingly widened uses of synthetics during the war years was the progress, both scientific and industrial, that had been going on, particularly since the 1870's, although for the earlier beginnings, it is necessary to go back still farther to the second quarter of the 19th century.

Of particular importance in evaluating the industrial and economic aspects of synthetics is the fundamental fact that modern synthetics are made chiefly from abundant and low-cost raw materials, many of which are by-products of other and long-established industries.

The multiplicity, no less than the versatility, of modern synthetics is little short of astounding; the sequence of their development during the past 100 years and more, in association with scientific and technologic advances made on a broad front, together with a recognition of the variety of uses to which they are put, constitutes one of the most brilliant chapters in the history of science and industry.

In a larger sense, however, these greatly varied developments embracing the entire realm of synthetics are to be viewed in perspective as an outgrowth of the Industrial Revolution, the latter being primarily based upon the large utilization of minerals.

The term plastics refers to certain physical properties of a substance and not to any specific chemical composition; the physical characteristics of a substance, however, are determined to a large extent by its chemical composition. Furthermore, there is no universal plastic best suited to all the numerous uses to which they are put.

Naturally occurring plastics have been used since prehistoric times. The Babylonians knew and used asphalt and pitch; and amber from northern Europe was a trade commodity that was carried far and wide. Rosin is a natural resin. In the wider sense of the term, clay is a plastic, as also is glass.

As commonly understood, however, synthetic plastics are mainly products of the 20th century. It is important, however, to note that much of the chemical groundwork upon which the entire modern synthetics industry is built was done in the 19th century. Just as the inception of the Industrial Revolution in England was preceded by a century of outstanding scientific achievement, so were the commercial developments in the field of synthetics of the 20th century based to a considerable extent upon scientific accomplishments of the 19th century. The bulk of their commercial development, however, has come only since World War I.

Any broad consideration of the development of plastics in either a scientific or an industrial sense requires that attention be given to developments in interrelated fields, especially those of synthetic fibers and synthetic rubber. It seems appropriate to quote from an English scientist that "Developments in plastics and associated chemical activities are keyed to a large synthetic rubber industry." And speaking of the English synthetic rubber industry, this writer continued: "We shall in due course regret our backwardness and reluctance to take the plunge." Like natural rubber and natural fibers, synthetic resins and plastics, it is important to point out, are composed of giant molecules.

As aptly summed up by Gordon M. Kline of the Bureau of Standards, in the 1941 "Annual Report of the Smithsonian Institution":

"The modern plastics industry deals chiefly with moldable materials manufactured from organic compounds, that is, combinations of carbon with hydrogen, oxygen, nitrogen, and other elements. The inorganic molding materials, such as concretes, cements, and ceramics, and also rubber, an organic substance, are not generally included within the scope of the plastics trade as it is known today, inasmuch as the industries utilizing these materials are considerably older and were already individually organized and developed prior to the advent of the newer plastics."

Sequence in Development

For a period of 100 years prior to the close of World War I, during which much of the scientific groundwork for the large production of synthetics was being laid, progress in the commercial development of these substances was slow indeed. What synthetics, or semi-synthetics, as were produced in the years following 1870 were based upon the utilization of naturally occuring materials, such as wood, cotton fiber, coal, skimmed milk. Even formaldehyde was produced from the destructive distillation of hard woods. It may be noted that the commercial use of sulphite pulp manufacturing processes did not begin until the early 1880's.

Since the entire field of synthetics has become widely inclusive in scope and is exceedingly complex as regards the chemical nature of the raw materials, intermediates, and products, this article emphasizes the historical phases in the rise of these industries. Such a presentation not only affords the necessary background as well as a perspective of the field as it has evolved with ever increasing tempo, but also proceeds from the comparatively simple conditions which prevailed in the earlier stages of development in synthetics to the extremely complex phases which have become so significant during the past few years.

The inception of scientific investigations in this great field may be said to have begun in 1826 when Michael Faraday determined that crude rubber is a hydrocarbon, having the empirical formula of C_5H_8.

1. Vulcanization of rubber by heating with sulphur, discovered in 1839 by Charles Goodyear, became a revolutionary technique, rendering crude rubber adaptable to a great variety of uses, even though methods other than that used by Goodyear soon came to be used in commercial vulcanization. Out of Goodyear's discovery came the growth of a new industry, and as James B. Conant wrote in 1939, "With the growth of this new industry came the growth of a new science—the chemistry of polymers, of large molecules." Practically considered, vulcanization—the combining chemically of sulphur with raw rubber—results in a product much less susceptible to temperature changes than crude rubber. It is now recognized that natural rubber is a polymer of isoprene.

Developments in the production of synthetic rubber has proceeded on the principle of building up large molecular units with elastomeric and other properties similar to those of crude rubber. In the same manner, the production of synthetic fibers and filaments is based upon the chemist's increasing knowledge of large molecules.

In 1839, Simon polymerized styrene, through thermal polymerization by the action of sunlight. Nearly 100 years, however, were to elapse before it was produced commercially. Styrene had been isolated by Benastre in 1831. Bertholet, in 1867, reacted benzene and ethylene to form styrene.

The French chemist, Paul Schutzenberger, is said to have first prepared cellulose acetate, in 1856.

In 1859 a patent for producing chlorinated rubber was taken out in England.

About 1860, Grenville Williams isolated isoprene, C_5H_8, from products of thermal decomposition (destructive distillation) of rubber.

2. John Wesley Hyatt in 1868 plasticized cellulose nitrate with camphor, thereby obtaining celluloid, the first of the man-made plastics. The raw materials were cellulose, nitric acid, and camphor.

The production of cellulose nitrate, generally regarded as the oldest type of synthetic material, and certainly the forerunner of the modern synthetic plastics industry, seems to have been started with the work of Schoenbein in Germany in 1845. Little, however, is known of Schoenbein's work. Next, Alexander Parkes in England did some work in this field in 1855, and to him is given credit for the first discovery of the plastic qualities of nitrocellulose. Then came the work of Hyatt, in making celluloid and collodion, 1869–1872. In spite of its high flammability, celluloid is still being produced commercially in large quantity.

In this connection it may be noted that nitroglycerine was first made in 1847 by the Italian, Sobrero, but for two decades its only use was as a heart stimulant! In 1855, Alfred Nobel used nitroglycerine mixed with kieselguhr, a diatomaceous earth, to make dynamite.

In 1875, Nobel discovered that nitrocellulose, (guncotton) can be gelantinized with nitroglycerine to form the base of smokeless powder.

Cellulose nitrate is made by treating cellulose (purified cotton linters, or highly purified wood pulp) with nitric acid. A heavy treatment gives the explosive, guncotton; a lighter treatment gives "soluble cotton," the base of the cellulose nitrate plastics. Collodion, for instance, is a solution of "soluble cotton" in alcohol and ether.

Cellulose nitrate itself is too hard and brittle to be widely adaptable. Hyatt's contribution consisted partly in the use of camphor as a plasticizer, and partly in that he worked with cellulose nitrate as a plastic mass rather than in solution. It may be of interest to note that camphor remains the most important plasticizer for the manufacture of these cellulose nitrate plastics, and, furthermore, camphor itself is now made synthetically. It may be recalled that Hyatt was a printer, and that he was endeavoring to make a substitute for ivory, to be used in the manufacture of billiard balls.

Hyatt's celluloid may be considered as the first plastic of importance in the history of the modern plastics industry; certainly, it inaugurated the actual commercial production of nitrocellulose plastics.

Attempts at producing a substance of less flammability than celluloid later on led to the commercial development of cellulose acetate and therefore indirectly into the synthetic fiber industry.

It may be noted that until the early 1930's the United States was the leading producer of nitrocellulose plastics, with Germany second; after 1933 Japan became an important producer of this material and some authorities believed that prior to World War II Japan had become the world's leading manufacturer of nitrocellulose plastics.

3. Baeyer investigated the reaction of phenol with aldehydes in forming resinous products in 1872, and in the same year, Bauman was investigating polyvinyl chloride. In 1873, Butlerow and Gariano prepared polyisobutylene. In 1879, the Frenchman, Bouchardt, in experimenting with isoprene, was the first to suggest that rubber is a polymer—a substance in which the molecules have been so linked together as to form a giant molecule. In 1894, Sir William Tilden obtained isoprene from turpentine; as stated by Marek, Tilden found that isoprene "spontaneously polymerized to a rubber substance when stored in glass and that this polymer united with sulfur in the same way as natural rubber to give a tough elastic compound."

4. In 1890, a casein-formaldehyde plastic was discovered by chance in Germany by Krische and Spitteler.

Chardonnet, who had been a pupil of Pasteur, produced in 1885 the first fibers of what today is called rayon. It is to be noted, however, that in 1883, Sir Joseph Swann patented in England a method for making fibers by extrusion of a solution of nitrocellulose in acetic acid into a coagulating bath. Swann was attempting to produce a satisfactory filament for the new incandescent lamps, which had been developed by Edison, but the method was essentially the same as the one which Chardonnet used for making "artificial silk" by the extrusion of collodion.

The viscose process for making rayon was introduced in 1892.

5. Baekeland announced his results in making phenol aldehyde resins in 1907. Baekeland's contribution con-

sisted not so much in combining phenol (carbolic acid) and formaldehyde as in the application of heat and pressure to the resulting substance, thereby producing a plastic material which can be molded and machined to form a multitude of articles. Bakelite is considered the first of the true commercial synthetics. Commercial production of Bakelite began soon thereafter, but growth in output was not very important until after World War I.

A factor in this growth in the 1920's was the lower cost of formaldehyde, due to the development of synthetic methanol and its large production; another factor, of course, was phenol—a coal-tar chemical—the production of which was inaugurated in the United States during World War I.

Formaldehyde has come to be produced commercially in large quantities by the catalytic oxidation of methanol, as well as by the catalytic oxidation of methane from natural gas. The bulk of the phenol production of the United States is now made synthetically, by conversion of benzene.

General Bakelite Company was organized in 1910. Bakelite Corporation was formed in 1922, by mergers. In 1939, this organization became a unit of Union Carbide and Carbon Corporation. The original Baekeland patents expired in 1926. In 1937 there were 36 different producers in this field alone.

Bakelite is prepared from wholly non-resinous, non-plastic raw materials—in contrast to rayon, for instance, which consists of a modified naturally occurring material, cellulose.

Baekeland was endeavoring to produce a substitute for shellac, a natural material then widely used and which at that time, owing to its widening industrial uses, was characterized by steadily rising prices. The use of shellac, which is a naturally occurring thermoplastic material for making phonograph records was introduced in 1895. Shellac is a natural product—the product of an insect which lives upon certain trees in India and southeastern Asia. Molded phonograph records are still made from a shellac base, although other materials are also being used. Shellac had, of course, been known and used for many centuries, chiefly for the making of sealing waxes, polishes, and varnishes.

Baekeland's synthesis, while a failure for producing a shellac substitute, proved, however, to be a starting point from which has stemmed a new and important phase of the chemical industry. Since the time of Baekeland's successful work, developments in the field of plastics have gone on at an ever increasing tempo, and especially so since the period of World War I. The phenolics, however, remain one of the large items of the plastics industry.

The rayon industry was introduced into the United States in 1910. The viscose process of making rayon uses either purified cotton lint or purified sulfite pulp as raw materials.

In the viscose process, the cellulose is thoroughly saturated at a closely regulated temperature in an 18 per cent solution of sodium hydroxide. After the excess caustic soda is removed by hydraulic presses, the material is mechanically shredded to "crumbs." The shredded material is kept two or three days at a uniformly cool temperature.

Following a proper aging period, the material is treated with carbon bisulphide and is then dissolved in a dilute sodium hydroxide solution, which gives a syrupy liquid. After being stored two or three days under carefully regulated temperature conditions, the liquid is thoroughly filtered, after which it is ready to be "spun."

The solution, upon being forced through very fine orifices in spinnerettes, is formed into filaments or fibers; the fibers are then brought in contact with a coagulating medium consisting essentially of a solution of sodium acid sulphate, which hardens the filaments. The fibers are first washed; they are then treated with a dilute solution of sodium sulphide to remove any sulphur compounds, and after that they are bleached. The regenerated cellulose may also be made into the form of thin, transparent sheets, one of the trade names of which is Cellophane. Commercial production of Cellophane was begun in the United States in 1926.

Decade of the 1920's

The decade of the 1920's was marked by the appearance of new synthetics of diversified types. It was particularly a period in which investigations of petroleum and natural gas hydrocarbons began to be important, paralleling the extension of thermal cracking operations in petroleum refining.

1. Ethyl cellulose, a cellulose ether, was prepared in 1921. Hercules Powder Company began ethyl cellulose production in 1935, and the Dow Chemical Company followed in 1937.

2. Urea aldehyde resins were prepared in 1920.

Urea was first synthesized by Wöhler in 1828; the original synthesis, however, is so expensive as to be unsuited to large-scale industrial use. Urea is now produced by high-pressure synthesis of ammonia and carbon dioxide.

3. The year 1925 witnessed commercial production of polyvinyl acetate. Vinyl acetate, unknown to the 19th century, was first described in a German patent issued to Klatte in 1912. Polymerization of vinyl acetate was described by Klatte and Rollette in 1917.

Since the acetylene, upon which the production of vinyl acetate is based, has been made from calcium carbide, a product of the electric furnace, the manufacture of vinyl acetate has been localized at points where low-cost, particularly hydroelectric, power is available. Commercial production of polyvinyl acetate began in Canada about 1920.

Also in 1920, phthalic anhydride resins (the alkyds), which are polyesters, were introduced, although they had been investigated as early as 1901. Alkyd resins are made by combining glycerine with organic acids, the most commonly used being phthalic anhydride. Phthalic anhydride is prepared by catalytic oxidation of naphthalene. The early work on alkyd resins in the United States was carried on by General Electric Company in the period, 1910–1916, in the production of "Glyptal." During this period phthalic anhydride was scarce and costly; after World War I, a new process for making phthalic anhydride (developed during the war period) made possible large-scale production. Other organic acids, maleic anhydride, and less so, succinic acid, are used in making certain types of alkyd resins, but these

are more expensive than those made with phthalic anhydride. Maleic anhydride is made by direct synthesis from benzene, although small quantities are obtained as a by-product in making phthalic anhydride.

The alkyd resins have been used almost exclusively for coatings and finishes, that is, in the paint, varnish, and lacquer fields. They are used extensively in baking enamels, e.g., finishes for household refrigerators, and also as automobile finishes. In brief, alkyds have become well nigh indispensable for the production of protective coatings which are in great demand for military uses.

4. In 1926, synthetic phenol was prepared from chlorobenzene. Durez Plastics and Chemicals, Inc., built a plant in 1940 in which the Raschig process is employed. By means of this method, benzene is converted into phenol through direct oxidation.

Phenol is a coal-tar product, produced in part by distillation of by-product coal tar, and in part from benzene by certain chemical processes. That produced from benzene is designated as "synthetic" phenol. Most of the phenol currently produced is the synthetic variety.

5. In 1927, cellulose acetate plastics, which are cellulose esters, were introduced, and in the following year, urea formaldehyde resins were produced in the United States.

Cellulose acetate is made by treating cellulose (purified cotton linters) with glacial acetic acid and acetic anhydride, in the presence of a peptizing agent, such as sulphuric acid. The glacial acetic acid serves mainly as the vehicle for the anhydride.

Cellulose acetate is soluble in acetic acid; as the reaction proceeds, the mass becomes a thick liquid.

Acetylation is stopped in the triacetate stage. At this stage the material is not soluble in acetone, although it is soluble in chloroform. The acetone-soluble material is produced during a "ripening" period. Dissolved in acetone, the material appears as a thick syrup, which can be extruded through fine orifices into warm air, thereby forming fibers.

Cellulose acetate is an ester of cellulose. On the other hand, rayon is regenerated cellulose—essentially cellulose slightly modified.

Small quantities of cellulose acetate had been used in England for making synthetic fibers and plastics prior to World War I.

Cellulose acetate had been used for photographic film in 1912; in the form of sheets, tubes and rods, it was put on the market in 1927 by the Celluloid Company. Molding materials became available in 1929. Injection molding machines were introduced into the United States about 1934—from which time the real use of cellulose acetate as a plastic dates.

Previously its high price had been a limiting factor on wide uses of cellulose acetate; new processes introduced in the late 1930's for the production of the basic chemicals—acetic acid, acetic anhydride, and acetone, all from propylene via isopropyl alcohol—used in its manufacture made these chemicals cheap and abundant; this permitted lower costs of cellulose acetate.

Tennessee Eastman's Tenite is a cellulose acetate, in the manufacture of which cotton linters are used as the raw material.

To sum up: The 1920's constituted a decade of rapid developments fundamental to the expanding synthetic fields; these developments were carried on through the 1930's, and, of course, were vastly stimulated by requirements of World War II.

Since 1930

Since 1930 there has been a continuous flow of new synthetics into the market; this period has been marked particularly by the increasing importance achieved by synthetics made from petroleum and natural gas hydrocarbons as raw materials for chemical conversion.

1. In 1929, Carothers began his investigation in the duPont laboratories of "linear" polymers—that is, materials the molecules of which form long chains, similar to the long-chain molecules of silk—through the study of polyesters, which are the condensation products arising from chemically reacting dibasic acids and glycols. Fibers from these polyesters were, however, unsatisfactory for use as textiles. The work went on in the hope of finding a super polymer which would yield strong, elastic and water-resistant fibers. In 1932, Carothers described polyamide fibers. Carothers and his co-workers developed the first of the American synthetic rubbers, Neoprene (then called Duprene), which was an outgrowth of their investigations in polymer chemistry. This work had been preceded by that of Julius Nieuwland, at the University of Notre Dame, who for years had investigated the polymerization of acetylene. Neoprene, a chloroprene polymer, was put on the market in 1932. In these investigations, the duPont scientists had come upon a group of "superpolymers," which upon preparation in fiber form, had amazing strength and elasticity. In 1938 nylon polymer was introduced and polyamides were produced commercially in the United States. The scientific achievements of the brilliant Carothers opened up vast new fields for further industrial developments on a wide front. As summarized in a recent address by Roger Adams:

"The formation of these large molecules, usually chain-like in structure, can be compared to the mechanical tying together, end to end, of a large number of short pieces of twine until a very long single string results.

"Bakelite, the first of these synthetic complex substances to be produced commercially a few decades ago, was developed on a cut and try basis by combining many molecules of carbolic acid and formaldehyde together. Until recent years, no careful scientific study was made to provide general laws by which the synthesis of these giant substances would be formed.

"It was primarily through the carefully planned and ingenious research program of the late W. H. Carothers and his staff that a systematic knowledge of synthetic procedures for this type of complex molecule was acquired. The first experiments explored the conditions by which the small molecules could be made to combine with each other until very large ones resulted, without having the process stop at some intermediate stage and yield products which did not have inert properties."

Commercial operations are summarized briefly by George Albee in *The Du Pont Magazine*, November-

December, 1944: "The gases at Belle (West Virginia) may be combined under high pressure, and with several different catalysts, to form phenol, dibasic acid and diamine. And these three chemical intermediates, combined in turn, yield the nylon salt which after refining becomes nylon of the type used in spinning yarns. Nylon is not a single product but a whole family of related polyamides; a large number of different nylons for different purposes can be manufactured."

In 1940, some 8,000,000 pounds of nylon were produced in the United States, just 5 years after Carothers had discovered the polymer.

2. The decade of the 1930's also witnessed the rise of the vinyls, as well as almost spectacular developments in the field of synthetic rubbers. The vinyl resins comprise a large family of thermoplastics—the intermediates of which are in part derived from either acetylene or ethylene. Polyvinyl chloride and vinylidene chloride had been prepared by Regnault as early as 1838. In the commercial production of polyvinyl chloride, either ethylene or acetylene may be used; polyvinylidene chloride is made from chlorinated ethane. Polyvinyl acetate was unknown until 1912; it is prepared by reacting acetylene and acetic avid. Vinyl acetate copolymer was produced commercially in the United tates in 1932. The vinyl plastics include polyvinyl acetate, polyvinyl chloride, copolymer of vinyl acetate and vinyl chloride (Vinylite V, of Carbide and Carbon), polyvinyl alcohol, polyvinyl butral, polyvinyl formal.

Hydrolysis of polyvinyl acetate to yield polyvinyl alcohol was described in 1927.

Polyvinyl chloride resins were first produced commercially in the United States in 1931, as also were acrylic resins in the same year.

Polyvinyl butyral plastic occupies an outstanding position in its use as the binder in laminated glass for automobiles and airplanes, having displaced cellulose acetate for this use since 1935. Polystyrene is regarded as suitable for this purpose, and with low production costs, it might compete successfully with polyvinyl butyrate in the postwar period.

Research work in the development of synthetic rubber goes back to the close of the 19th century; the bulk of the developments leading to the successful commercial production of these synthetics, however, belongs largely to the 1930's.

Polychloroprene rubber was described and production was begun in 1931. In 1927, Father Nieuwland had announced the polymerization of acetylene to monovinylacetylene, which, however, it has not been possible to convert into rubber. In 1931, the announcement was made that monovinylacetylene could be converted to chloroprene by treatment with hydrogen chloride in the presence of a suitable catalyst. Chloroprene polymerizes readily, yielding neoprene.

In the 1920's, Patrick produced by accident a polysulphide rubber, Thiokol, while endeavoring to make a low-cost antifreeze. In making the original Thiokol, ethylene was chlorinated to form ethylene dichloride, which upon being treated with sodium tetrasulphide yielded a rubber-like resin and a patent was applied for in 1928. According to Marek: "Since that discovery, it has been found that many other organic dichlorides could be condensed with sodium polysulfide to give rubbery materials. For instance, the use of dichlorodiethyl ether instead of ethylene dichloride gives a more rubber-like material than the original Thiokol."

Thiokol was introduced commercially in 1932. Thiokols, of which there are a large number, are manufactured by the Dow Chemical Company. The selling agency is the Thiokol Corporation. Thiokols are inherently low-cost products, due to the fact that the raw materials for their production are abundant. The Dow Chemical Company has a Thiokol plant at Freeport, Texas.

Buna and Butyl rubbers. Kondakoff as early as 1900 reported that dimethyl butadiene could be converted to an "elastic mass." As summarized by Marek: "By thus departing from the classical efforts of his predecessors, Kondakoff laid the foundations for Germany's wartime synthetic, 'methyl rubber.' . . . The Germans . . . turned to butadiene and more especially to dimethyl butadiene which was derived from acetone as their starting point. The acetone was obtained either from fermentation of potatoes or from calcium carbide-derived acetylene."

The Germans produced some 2,300 tons of "methyl rubber" from dimethyl butadiene derived from acetone during World War I—the first synthetic elastomer produced on a commercial scale. Methyl rubber, however, proved unsatisfactory.

The status of synthetic rubber development in Germany at the end of this period was such that in 1918 Fritz Hofmann, who had pioneered Germany's methyl rubber production, gave up in despair, and turned to what he considered to be more promising fields of research.

In the meantime the Russian chemists who followed Kondakoff in the field of synthetic rubber had turned to butadiene as a likely raw material.

In 1910, Lebedev showed that heating butadiene yielded a rubber-like polymer. In 1911, a similar result was reported by Harries in Germany.

In 1915, Ostromislensky showed that butadiene could be made by the pyrolysis of a mixture of alcohol and acetaldehyde. In this connection, the English scientist, Harry Barron, in his recent book on "Modern Synthetic Rubbers" states that "Ostromislensky was the pioneer of a process which was the forerunner of some of the most modern methods. . . . In fact with the passing of time, it begins to appear that Ostromislensky is the outstanding figure in synthetic rubber history." And at another place, Barron observes: "Incidentally, Ostromislensky, in the course of his researches for synthetic rubber, carried out much of the fundamental work which has led up to the commercial application of polyvinyl resins, notably with vinyl chloride."

In 1925 Lebedev succeeded in polymerizing butadiene with sodium. It is appropriate to note that the Germans had not developed their Buna type of synthetic rubbers prior to 1925. After 1929, particularly, I. G. Farbenindustrie was especially active in the field of synthetic rubber.

During the 1930's, German chemists continued their investigations of synthetic rubbers made from butadiene: copolymers of butadiene and styrene to make Buna-S, and of butadiene and acrylonitrile to make Buna-N. According to Marek: "The modern history of rubber in Ger-

many is intimately linked with the ambitious undertakings of the I. G. Farbenindustrie to dominate the European chemical industry and to penetrate deeply into world chemical markets, with the rise to power of Hitler, and with the pressure of nationalism, . . . At about the time, 1933, Germany's plans for industrial self-sufficiency received additional impetus and too by this time I. G. had achieved far-reaching penetration into world chemical industry. . . . Apparently the government had come to dominate the work of I. G. Farbenindustrie by 1935."

Butyl rubber, made by copolymerizing isobutylene with a small amount of butadiene or isoprene, is entirely an American development. Polymerization of isobutylene yields Vistanex—which is so completely saturated as not to be susceptible of vulcanization. On the other hand, Butyl rubber, the copolymer of isobutylene and isoprene (or isobutane) can be vulcanized.

3. Vinylite V or Vinyon was originally made by Carbide and Carbon Chemicals Corporation, to whom a patent was issued in 1937.

This synthetic substance, the product of extensive research on vinyl polymers, is a copolymer of vinyl chloride and vinyl acetate, made by polymerization rather than by condensation. American Viscose Corporation began the manufacture of Vinyon filament yarn and fiber in 1939.

Production of polystyrene was begun in 1937 in the United States, by Dow Chemical as well as by Bakelite Corporation, although it had previously been made in Europe. Styrene polymerized with butadiene yields Buna-S synthetic rubber, or GR–S as it is now designated.

The "acrylic" resins were introduced in the United States in 1931, by Rohm and Haas Company, Inc. In 1937 polymethyl methacrylate was introduced by duPont, under the trade name, Lucite. The acrylic resins are polymers of methyl acrylate or of methyl methacrylate. Methyl methacrylate is a derivative of acetone, the latter being made now in large quantities and at low cost chiefly from propylene as the raw material, the latter being a constituent of cracked refinery gases. The spontaneous polymerization of acrylic esters had been known since 1873, but the commercial rise of the acrylic resins resulted from the research work on acetone which was carried out during World War I.

In 1939, commercial production of melamine resins was begun in the United States. In 1940, polyvinylidene chloride was produced commercially.

In 1938, cellulose acetate butyrate was introduced, by Hercules and by Tennessee Eastman (Tenite II). In 1940, melamine formaldehyde was introduced by American Cyanamid Company. In the same year, as already noted, nylon which is also used as a plastic was first produced commercially by duPont.

Polythene (polymerized ethylene), developed by Imperial Chemicals Industries, Ltd., was being produced in Great Britain in 1941.

Polythene, or polyethylene, was in commercial production in the United States during 1944, being manufactured by duPont and Carbide and Carbon. As summarized by R. L. Bailey, *The duPont Magazine*, November-December, 1944: "Chemically, polythene is the simplest of all the synthetic thermoplastics. Manufactured by the polymerization of ethylene under extremely high pressure, small molecules of the gas unite like a chain of paper clips to form the solid plastic. Polythene is composed of long methylene chains, each 'link' or unit of which is made up of one carbon atom and two hydrogen atoms. These chains range in length from around 200 methylene units up to a thousand or more."

Polyvinyl alcohol has been made in quantity only since 1941. Polyvinyl alcohol is prepared by hydrolyzing polyvinyl acetate. Vinyl acetate is formed by reacting acetylene with acetic acid.

4. In 1942, Saran, a copolymer of vindylidene chloride, was announced. Vinylidene chloride is produced from ethylene and chlorine, which are combined to form trichloroethane, which in turn is converted to vinylidene chloride. Nylon, Vinyon, and Saran are plastics, but these materials are also prepared as fibers. A common property of these substances is that they can be "cold-stretched," a process that increases their tensile strength.

Two other new plastics were announced in 1942, both of which are made from allyl alcohol. Shell Chemical Company announced a polymer of diallyl phthalate and the Columbia Alkali Division of Pittsburgh Plate Glass announced what was first designated as C.R.–39 and which is now called Allymer–39.

Styraloy, a copolymer of styrene and butadiene, was announced in 1943. The Dow Chemical Company will construct a million dollar plant to manufacture this plastic on a mass production basis. As to its physical nature, Styraloy has been described as a cross between plastics, rubber, and wood. GR–S synthetic rubber is also a copolymer of butadiene and styrene.

5. In 1944, silicones (organo-silicon compounds), built upon the chemical combination of silicon and oxygen, were put into production by Dow Corning Corporation and General Electric Company. Silicones are available not only as resins, but also as fluids, greases and lubricants.

Silicones, comprising an entirely new and unique type of high polymers, have been described as being intermediate between organic resins whose usefulness is limited by heat stability, and the inorganic ceramic-type materials which have no such limitations. Industrially, the silicone resins have a wide field of application in electrical equipment.

Classes of Plastics

The most commonly used classification of plastics is based on the physical behavior of the substances to repeated applications of heat; plastics are therefore classified as thermoplastic (heat-softening) or as thermosetting (heat-hardening).

Thermoplastic substances become soft when heated for the first time above a certain point and harden upon cooling; upon being reheated they soften again and harden when cooled. That is, thermoplastic materials are permanently fusible.

Thermosetting substances become soft upon being treated the first time but upon further heating, with

pressure, they harden permanently and becoming infusible, they cannot be "re-melted." That is, in contrast with thermoplastic substances, thermosetting materials may be rendered permanently infusible by heating. As John M. Weiss has stated: "It is this characteristic that gives them great industrial value since the finished articles withstand elevated temperatures and resist the action of solvents and other chemicals."

Thermoplastic substances are those whose synthesis depends on polymerization—the linking together of relatively simple molecules to yield products of high molecular weight; these high polymeres are solids which can be softened by heat or a solvent, or can be mixed with plasticizers. They are composed of long molecular chains—long, thread-like "linear polymers"—with little interlinkage. Thermosetting substances, on the other hand, are formed from monomers or intermediates which give a cross-linked, rigid structure—in which the individual chains are no longer mobile in relation to one another—hence they cannot be softened by the application of heat.

Groups of Major Synthetic Resins and Plastics

The following grouping of synthetic resins and plastics is based upon the classification used by B. H. Weil in an article "Plastics from Petroleum" in the *Petroleum Refiner*, January, 1945.

I. Formaldehyde resins.
   1. Phenolic resins, or phenol-formaldehyde group.
   2. Urea-formaldehyde resins.
   3. Melamine-formaldehyde resins.

II. Cellulose plastics.
   1. Cellulose nitrate.
   2. Cellulose acetate.
   3. Cellulose acetate-butyrate; cellulose acetate-propionate.
   4. Ethylene cellulose.
   5. Methyl cellulose.

III. Ethenoid resins.
   1. Polyvinyl chloride.
   2. Polyvinyl acetate.
   3. Copolymer of polyvinyl acetate and polyvinyl chloride. (Vinyon; Vinylite V).
   4. Polyvinyl butyral.
   5. Polyvinylidene chloride, from chlorinated ethane. Saran is a polymer of vinylidene chloride.
   6. Polyvinyl alcohol derived from polyvinyl acetate.
   7. Polystyrene.
   8. Polythene.
   9. Acrylic resins. Methyl methacrylate, from acetone; acetone, in turn, from propylene, by way of isopropyl alcohol.

IV. Polyamides, of which nylon is typical. The starting material is benzene. Benzene is converted to phenol, which is hydrogenated to cyclohexanol. Cyclohexanol is dehydrogenated to cyclohexanone, which is converted by oxidation to adipic acid. Part of the adipic acid is converted to the desired diamine, by addition of ammonia. The diamine by condensation polymerization with adipic acid yields nylon.

V. Allyl resins: dependent upon allyl chloride and allyl alcohol, which in turn are produced from propylene.

VI. Alkyd resins.
   1. Phthalic anhydride resins.
   2. Maleic anhydride resins.

VII. Organo-silicon compounds.
   Silicones are polymers built on a silicon-oxygen framework, instead of the usual carbon chain structure. Raw materials include silicon and chlorine for producing silicon tetrachloride, as well as "organic chlorides and magnesium for converting the silicon tetrachloride to magnesium organo substituted silicon chloride." The resulting substance is then converted to silicones, by hydrolysis and polymerization.

Cellulose Plastics

The large group of cellulose plastics utilize the naturally occurring long-chain molecules of cellulose as the basic raw material. These are supplied mainly from cotton linters and purified wood pulp. The character of the products is determined by the processing chemicals used and the degree to which the cellulose is affected by such chemicals.

Of the cellulose plastics, cellulose acetate, also important as a fiber, is at the present the most important type. Cellulose acetate plastics were introduced commercially in the United States in 1932.

Both acetic anhydride and acetic acid are required in its manufacture. Acetic anhydride is produced mainly from propylene, through a series of reactions involving isopropyl alcohol, acetone and ketene; acetic acid reacted with ketene gives acetic anhydride. Acetic acid may be made either from acetylene or from ethyl alcohol; ethyl alcohol is made in quantity from ethylene.

In this connection it may be noted that a press dispatch of June 17, 1945, announced that the huge chemical plant of Celanese Corporation of America at Bishop, Texas, is ready to begin the production of such intermediates for plastics, synthetic textiles, and explosives, as methanol, formaldehyde, acetic acid and acetic anhydride. These intermediates will be made from raw materials supplied by natural gas.

Cellulose acetate-butyrate plastics comprise a modification of cellulose acetate plastics. Butyric acid is used along with acetic acid in the manufacture of these plastics.

Nitrocellulose plastics are extensively used in the manufacture of motion-picture and other photographic films, although they have been replaced to some extent by "safety film" made from cellulose acetate.

The cellulose plastics previously described are cellulose esters; that is, cellulose nitrate and cellulose acetate are substances formed by combining the cellulose molecule with acids. Two cellulose ether plastics, ethyl cellulose and methyl cellulose, are being produced commercially; these are formed by combining the cellulose with alcohols, although not directly.

Ethyl cellulose plastics require ethyl chloride as an intermediate in their manufacture. Ethyl chloride can be made by reacting either ethyl alcohol or ethylene with hydrogen chloride. Besides its use in the production of ethyl cellulose, ethyl chloride is also an intermediate used in producing other substances, one of the most important being tetraethyl lead. Methyl chloride, used in the production of methyl cellulose, can be made by the chlorination of methane.

Ethyl cellulose somewhat resembles cellulose acetate, but is more costly than cellulose acetate, which somewhat limits its commercial applications.

Formaldehyde Resins

Essential raw materials of the formaldehyde resins include besides formaldehyde, phenol, and urea. The phenol-formaldehyde and urea formaldehyde resins belong to the group known as condensation polymers.

As summarized by B. H. Weil in the *Petroleum Refiner*, January, 1945:

"The resins make use of the reactivity of formaldehyde (CH_2O) with a hydrogen atom of certain compounds (phenol, urea, melamine) to form the group CH_2OH; this group then reacts with another hydrogen atom of a similar joint compound, with the splitting out of a water molecule, and long and cross-linked chains are thus built up, the—CH_2— group serving as a binder. As will be recognized, these resins are condensation resins and are thermosetting in nature. Formaldehyde itself, . . . is produced either by the catalytic oxidation of methyl alcohol (derivable from natural gas), or, to a lesser extent, by the oxidation of such gases as butane. Other aldehydes than formaldehyde, such as furfural, are sometimes used to impart different properties, but formaldehyde itself finds by far the greater use."

Resins of the phenolic branch of the formaldehyde group are produced from phenols and (generally) formaldehyde. Bakelite and Durez are typical representatives of the phenolic plastics.

Quoting again from B. H. Weil: "In general, the phenols are obtained from coal carbonization by-products, but in recent years increasing quantities of cresylic acids (as mixtures of phenols are called) have been produced from petroleum, and the production of benzene from petroleum may now provide the chief raw material for phenol itself."

As to the urea-formaldehyde resins, the urea used therein is made through high-pressure synthesis from carbon dioxide and ammonia; raw materials obtainable from natural gas can be used in their synthesis.

The melamine resins contain amine groups, which upon reacting with formaldehyde, yield what are termed interlinkable intermediates. Melamine resins were not introduced until 1940.

Plastics from Petroleum

Plastics prepared from chemical intermediates derivable from petroleum include particularly the ethenoid group and new allyl resins. The importance of petroleum and natural gas hydrocarbons as starting materials in the entire field of synthetics has been noted in the series of articles of the Review. It is appropriate, however, to emphasize again that ethylene, propylene, butylenes and amylenes, as the Englishman, Dr. A. E. Dunstan has written, "are the authentic chemical bricks of our new synthetic chemistry—the chemistry of rubber, of plastics, and of polymers of various degrees of complexity."

Ethenoid Resins

Of the ethenoid group, the vinyls or polyvinyl resins group probably constitute at present the most important branch. In the synthesis of these resins numerous petroleum chemicals are employed.

The simplest vinyl compound, ethylene, polymerizes only with some difficulty. Vinyl chloride on the other hand, polymerizes readily. In fact, vinyl chloride and vinylidene chloride, together with their polymers, had been prepared as early as 1838 by Regnault. In contrast, the polymerization of ethylene, by high-pressure synthesis, was not achieved until very recently, the original synthesis, which yields polythylene, having been made by Imperial Chemical Industries, Ltd., of Great Britain, about 1941.

Vinyl chloride can be produced either by the "high-temperature substitution reaction of chlorine on ethylene or by the addition of hydrogen chloride to acetylene." Ethylene and acetylene, as well as hydrogen for hydrogen chloride all are being produced or are producible from petroleum and natural gas.

Vinyl chloride at atmospheric conditions is a gas; when polymerized with the aid of suitable catalysts, it is converted into a solid—the resin, polyvinyl chloride.

One of the synthetics made from polyvinyl chloride is Koroseal. As summarized by Marek: "Koroseal, the result of research and development by the B. F. Goodrich Company, is a synthetic, elastic material made by the plasticization of polyvinyl-chloride. Variations in properties from a soft gel to a rigid, hard material may be obtained. The substance is a true thermoplastic and is not capable of vulcanization."

In February, 1945, Goodyear Tire and Rpbber Company announced that construction would shortly begin on a new $1,500,000 chemical plant at Natrium, West Virginia, for the manufacture of a wide variety of new "rubber-like" plastics, known as vinyl chloride copolymers. The capacity of the plant is to be 3 million pounds annually. Vinyl chloride will be made by a catalytic process from acetylene and hydrogen chloride. The plant will also make a number of other organic compounds that will be used in the copolymerization process.

Vinyl acetate is produced by reacting acetylene with acetic acid. Acetic acid may be produced from ethyl alcohol or from acetylene. Vinyl chloride and vinyl acetate are the bases for most of the vinyl products in commercial production.

Polyvinyl alcohol is made through hydrolysis of polyvinyl acetate. Polyvinyl acetals can be made by reacting polyvinyl alcohol with various aldehydes, for example, butraldehyde, obtainable synthetically from acetaldehyde—which in turn is derivable from either acetylene or ethyl alcohol.

Vinyl chloride can be copolymerized with vinyl acetate —the latter being a compound closely related to vinyl

chloride. The resulting copolymer—the trade name for which is Vinyon, is a synthetic fiber as well as a synthetic resin.

Styrene is now being produced in the United States at a rate in excess of 200,000 tons annually, as a part of the synthetic rubber program.

The plastic, polystyrene, is a polymer of styrene; the latter is made by alkylating ethylene and benzene, followed by the dehydrogenation of the resulting product. Ethylene can be extracted from cracked refinery gases or it can be made through pyrolysis or cracking of petroleum fractions such as propane. The resin, polyvinylidene, represented by Saran, is made from chlorinated ethane.

Polyethylene plastics, as previously noted, are made from ethylene. Both polystyrene and polyethylene are low-cost materials.

Acrylic or acrylate resins. The acrylic resins are polymers of either methyl acrylate or methyl methacrylate. Essential raw materials for making the methacrylate group of resins include acetone, methanol, and hydrocyanic acid. As summarized by John M. Weiss in *The Wall Street Journal*, February 14, 1940: "The term 'acrylate' resins comprises a number of types of products made from various derivatives of acrylic acid, the most common one being the methyl ester of methyl acrylic acid. The chemistry of these compounds is quite complicated and no attempt will be made to discuss it. The basic materials used to produce the acrylic acid derivatives are ethylene chlorohydrin and acetone.

"Both of these materials are today produced from the hydrocarbons of cracking oil gases. Ethylene chlorohydrin is made for the most part by Carbide and Carbon Chemical Company. This firm also produces acetone from oil gas as does the Shell Petroleum Company. . . .

"The processes of making acrylic acid and its derivatives also require sodium cyanide (a product made by duPont and American Cyanamid and Chemical Co.) as well as various alcohols such as ethyl alcohol and methanol."

Methyl acrylate is now but little used, having been largely replaced by methyl methacrylate.

Methyl methacrylate is derived chiefly from acetone, which in turn is produced chiefly from isopropyl alcohol; the production of the latter is supplied almost exclusively from propylene. This development exemplifies another important reaction in the expanding realm of plastics to the availability of abundant and low-cost acetone, derived from a petroleum product. Acetone is reacted with hydrocyanic acid; the resulting product is then reacted with methyl alcohol. Hydrocyanic acid is made from ammonia and hydrogen. Methyl alcohol (methanol) can be produced either by high-pressure synthesis of carbon monoxide and hydrogen, or by controlled oxidation of natural gas. Lucite and Plexiglas are trade names of methyl methacrylate resins known to many.

Allyl Resins

The allyl group of resins has been introduced during the war. Production of allyl resins (one of which is Allymer–39) and which are the hardest of the transparent plastics, is based on allyl alcohol, derived from allyl chloride, which in turn is dependent upon propylene. Shell Oil Company has under construction a million dollar unit at its refinery on the Houston Ship Channel which will make allyl chloride and allyl alcohol from propylene gas.

Alkyd Resins

Essential raw materials of the alkyd group of resins include glycerol and phthalic (or maleic) anhydride.

Alkyd resins are used largely for protective coatings and finishes.

As summarized by B. H. Weil in the *Petroleum Refiner*, January, 1945: Alkyd resins are formed by the "condensation of polyhydric alcohols (such as phthalic anhydride, maleic anhydride, fumaric acid, and abietic acid), chemically combined with oils and other modifiers. Sold under a variety of trade names, such as Glyptal, Pentalyn, Amberlac, and Teglac, these resins yield excellent paints and finishes and are used for coating vast quantities of military equipment, just as in the past they excelled in automobile finishes. Other uses abound. Phthalic anhydride usually is produced from naphthalene, but at least one petroleum company is now engaged in its manufacture. Maleic acid usually is derived from benzene but may be produced from a variety of chlorinated hydrocarbons, to mention one process; so may fumaric acid."

Glycerine, although producible from propylene, is mainly supplied as a by-product of soap making.

Naphthalene was not produced commercially in the United States prior to World War I. For some years after the war, its uses were limited mainly to the production of moth balls and dye stuff intermediates. The resulting demand was not large nor was there any promise for much growth in this demand. The technologic development whereby air oxidation of naphthalene yielded phthalic anhydride, completely changed the picture, as this process provided a new raw material which served as a starting point for several new activities. These new uses have been greatly stimulated by World War II.

Naphthalene, from which phthalic anhydride is produced, is a distillate from coal-tar, which means it is largely a by-product of coke manufacture. Current prices and production of naphthalene are dependent upon the economies of this by-product relationship. So great, however, are the current demands for phthalic anhydride that the possibilities of its by-product sources are practically exhausted. As noted in a preceding article in the Review, one company plans to produce phthalic anhydride from ortho-xylene, a petroleum derivative.

Nylon

Nylon, a polyamide polymer, is an entirely new material, wholly synthetic, different in properties from any of the previously made synthetics. Nylon is made into yarn and bristles, the latter being used for brushes; nylon is also a thermoplastic material.

The first commercial plant for the production of nylon yarn went into operation early in 1940, at Seaford,

Delaware. The capacity of this plant was 8,000,000 pounds a year.

A second nylon yarn plant, virtually a duplicate of the first one, and of the same capacity went into operation late in 1941, at Martinsville, Virginia, in the Blue Ridge foothills. The cost of this second plant was $11 million.

A new plant for the production of nylon polymer, commercially designated as nylon salt, was under construction at Belle, West Virginia, in 1941.

DuPont is now constructing a $22,000,000 nylon-salt plant at Orange, Texas. Nylon salt is made from two complex chemicals, adipic acid and hexamethylene diamine.

Adipic acid can be made from cyclohexane, and the hydrogen for this operation can be supplied from natural gas. Cyclohexane occurs in lighter distillate of what is called the naphtha fraction from certain crude oils.

The other component used in making nylon salt, hexamethylene diamine, is made from adipic acid and ammonia. The hydrogen for ammonia synthesis can be made from natural gas.

The case of nylon may be used to illustrate the current situation with reference to a number of synthetic chemicals, especially as regards their interrelations. As John M. Weiss has written, *Chemical & Engineering News*, January 10, 1945: "The postwar situation in benzene has certain elements of uncertainty. It seems that there will be a greater percentage immediate postwar recession in synthetic phenol use than in phthalic anhydride use and that the use of styrene in the rubber program may also be curtailed. But it is highly probably that synthetic rubber is here to stay. Furthermore, there are great potentialities in both phenol resins and styrene resins which have hardly been exploited. Nylon, which depends on benzene as the base of adipic acid, will undoubtedly grow. It is readily conceivable and even most likely that over a short space of years we will have demands for benzene exceeding that available from our coke-oven light oil supply. Expansion will then depend on a cheap source of new production and the only possibility appears to be petroleum. Benzene can be produced by cracking petroleum with somewhat more difficulty than when toluene is made. So far, the economics of benzene production is not as clear as in the case of toluene, so that it cannot be surely predicted whether costs will be of an order to allow unlimited expansion in products based on benzene."

Trends Exhibited in the Growth of the Plastics Industry

The older types of plastics, the thermoplastic cellulose derivatives, together with the thermosetting resins, such as the phenolic (or tar-acid) and urea resins, are all more or less conditioned in production by the limitations of specific raw materials, a situation which is being somewhat high-lighted during the war.

New Materials and Improved Techniques

The newer type of resins are truly synthetic and wholly so. Their production is based upon the development of more adequate polymerization methods and techniques. Factors influencing the physical properties of the final plastic material, with an eye on its range of versatility, can be more fully taken into account in their manufacture.

Their raw materials are varied; in many cases, the raw materials are interchangeable.

In this newer group, most of which are thermoplastic, belong styrene, butadiene copolymers, ethylene polymers, the vinyl polymers, vinylidene chloride, the acrylates, nylon, the allyenes, as well as others—all of which have been attracting special attention in the last few years.

This newer group of plastics will be important in bringing plastics out of the gadget category and into more fundamental applications, which require intermediates in large quantities, and which therefore can well take advantages of the economies of mass production. In this connection it is of great importance that many of the raw materials for these resins and synthetics are relatively low in cost and are rather readily available; many of the raw materials are being supplied from petroleum and natural gas hydrocarbons.

Quoting from the *Industrial Bulletin* of Arthur D. Little, Inc.,

> One common denominator, unsaturation, runs through most, though not all, of these thermoplastics. A carbon atom is unsaturated when it has less than its full complement of other elements or groups attached to it. The unsaturated carbon atom is particularly reactive and joins easily with other carbon atoms. In so doing it can act as a link joining together, or polymerizing, large molecular groups to form a long chain, so that finally several hundred of the molecules are strung together in a long, thread-like linear-polymer—a solid which can be softened by heat or solvent, or mixed with plasticizers, and entrusted to the mechanical engineer to form. Thus styrene liquid becomes glass-clear polystyrene; vinyl chloride gas becomes solid polyvinyl chloride; and mixtures of butadiene and acrylic nitrile become synthetic rubber. The properties of this thread skeleton are profoundly influenced by its length, which determines its toughness, and by the various chemical groups which it may contain. If the chemist needs toughness over a long temperature range, he may occasionally bond one chain to another—with sulphur in synthetic rubber—but he avoids too many of these "cross linkages" because they tie the molecules up so tightly that brittleness may result.
>
> The plastic which bonds two glass sheets to form safety glass is a fair example of the versatility of such products. It starts with vinyl acetate, a pleasant-smelling, volatile liquid resembling a lacquer solvent. The molecues of this are made to string together end-to-end to form a chewing-gum-like solid, polyvinyl acetate. Since this does not give the desired toughness over an adequate temperature range, or good water resistance, butyraldehyde is substituted for most of the acetate groups present. The resin resulting from all this tailoring and most of its immediate relatives now almost have the desired qualities, but are still too brittle when cold. By mixing in a plasticizer, toughness and flexibility in zero weather are attained.
>
> Chlorine-containing plastics, too, can be manipulated to the desired form. Chlorine, if tightly bound chemically, confers waterproofness and fire-resistance; polyvinyl chloride, however, softens at quite a high temperature. To lower its softening temperature a plasticizer may be added, or it may be co-polymerized with vinyl acetate, then slightly plasticized to give the tough sheet materials from which gaskets, cable insulation, wrist watch straps, and shower curtains are made.

High Polymers and Copolymers

The following quotation from R. F Boyer of the Dow Chemical Company appeared in *Ciemical and Metallurgical Engineering*, November, 1944. It is quoted here because it aptly summarizes so much of the principles underlying the production of synthetics, and at the same time it projects current scientific achievements into the

future where they may be translated in time into an even wider array of even more versatile materials.

One plastic differs from another primarily in the nature of the chemical group attached to the hydrocarbon chain . . .

It is now generally recognized that most high polymers of the thermoplastic type consist of long hydrocarbon chains with certain chemical groups substituted at regular intervals along the chain. For a given polymer, once a certain chain length is reached, mechanical properties become relatively independent of further increase in chain length. . . .

Copolymers allow one to build up a plastic material having almost any desired set of characteristics. The behavior of copolymers is not a simple additive function of their chemical composition but is more analogous to the case of metallic alloy systems where a small amount of an added constituent can influence mechanical properties all out of proportion to the amount present.

Three component systems show considerably more complexity than two-component system and one can begin to tailor a plastic molecule to fit any desired requirement. The field is relatively new, but the preliminary results are quite promising and indicate that more and more the plastics industry will be moving away from simple polymers into multi-component polymers.

Actually the problem of designing plastics for specific applications may not be as simple as indicated. One must choose not only the correct ingredients, but must also determine by patient trial and error the exact proportions of each to use. Moreover, the new ingredients in the copolymer must not achieve the final result at a sacrifice of other desired properties.

To summarize: Achievements in high polymer chemistry have come mainly in the past 25 years.

Synthetic polymers can be divided into two groups:

1) Those resulting from addition polymerization, the polymers and copolymers. These include such products as GR–S synthetic rubber, polystyrene, and other vinyl polymers. These processes are referred to as vinyl polymerization.

2) Those resulting from condensation polymerization, sometimes referred to as poly-condensation. Earlier products of this process include the phenol- and urea-formaldehydes and the alkyd resins. Systematic investigations of this group of reactions were first carried out by Carothers in the classic research work which led to the development of polyamides of the nylon type.

Advances in Machine Operations in Handling Plastics Materials

Molding with high pressures involves the use of the old-type hydraulic press. The principle of the hydraulic press was discovered by Pascal in 1653. In 1795, Joseph Bramah first applied the principle to a practical machine.

Little use, however, was made of this contrivance until after Goodyear's discovery of rubber vulcanization in 1839. It was used in the manufacture of rubber products and later came to be used in the molding of thermoplastic materials. The completely automatic compressing molding press for thermosetting resins was not developed until the late 1930's.

The injection molder, introduced into the United States from Germany about 1934, is employed in molding thermoplastic resins. The injection molder, which works on the same principle as the Linotype machine, makes possible the mass production of articles from thermoplastic resins. The injection molding technique has since been applied to thermosetting resins. The discovery of the injection molding principle is attributed to Edmond Pelouze who in 1856 developed a die-casting machine in which molten metal was forced into a die by mechanical or hydraulic means. Another technologic development in the use of plastics has to do with lamination processes. Laminates might be considered as a parallel to the principle of reinforced concrete; that is, plastic laminates are "reinforced plastics." The uses of laminates extends beyond their applications to plastics; the development of plywood, for instance, is based on this principle. Still another important application of laminates is exemplified in the making of safety glass.

Contact Pressure Resins

Still another new group of the rapidly growing plastics field embraces what are termed the "contact resins." Owing to the fact that these resins will "cure" on contact without the application of heat and pressure, the need for expensive, high pressure molding equipment is thus eliminated.

One type of these is the allyl resins, the basic raw material of which is allyl alcohol which has hitherto been a scarce chemical.

The contact resins have been developed during World War II; thus far production is small.

These new compositions are liquids; upon being treated, these resins partially harden to a state in which they resemble thermoplastics. Further heating hardens them to a non-melting or infusible state; in this sense, they resemble thermosetting resins.

According to the *Industrial Bulletin* of Arthur D. Little, Inc., October, 1944, these recently developed resins give promise of opening up new uses for plastics, "particularly in production of large complex shapes in which the resin may be impregnated into fibrous materials such as canvas. . . .

"In contrast to expensive, complicated equipment required for molding other types of plastics under pressure and at high temperatures, these resins require relatively low temperatures and only enough pressure to maintain the desired form."

In Concluusion

The field of plastics, together with the entire realm of synthetics, is illustrative of significant current trends in and at the same time reflect in no uncertain terms vast post-war potentialities of the chemical industry. That Texas has a huge stake in the further development of the United States chemical industry, and especially in the vast field of synthetics, no one will deny. Texas has already attained a high rank as a producer of chemicals, particularly of organic chemicals. Huge developments are now underway in the State which will greatly increase the output of synthetic organic substances that have become essential in the Nation's industrial structure. The Texas phase of the American chemical industry has achieved a position essential to national welfare, as abundantly illustrated by its contributions to the war effort. Past trends and current conditions, considered in relation to the State's endowment of natural resources, indicate that the industrial potential of Texas, especially as regards the further expansion of the chemical industry, is one of extraordinary promise.

Elmer H. Johnson.

EMPLOYMENT AND PAY ROLLS IN TEXAS
May, 1945

	Estimated Number of Workers Employed*		Percentage Change from		Estimated Amount of Weekly Pay Roll		Percentage Change from	
	April, 1945[1]	May, 1945[1]	April, 1945	May, 1945	April, 1945[1]	May, 1945	April, 1945	May, 1945
MANUFACTURING								
All Manufacturing Industries	168,713†	165,556†	− 1.9	− 0.5	$5,642,820	$5,440,498	− 3.6	− 4.2
Food Products								
Baking	10,561	10,402	− 1.5	+ 3.1	428,622	423,436	− 1.2	+16.5
Carbonated Beverages	3,463	3,466	+ 0.1	− 2.7	105,551	110,613	+ 4.8	+ 5.4
Confectionery	1,534	1,416	− 7.7	− 0.7	20,898	21,873	+ 4.7	+10.6
Flour Milling	2,493	2,490	− 0.1	+10.6	89,125	87,431	− 1.9	+22.3
Ice Cream	1,493	1,553	+ 4.0	+ 1.2	44,950	43,873	− 2.4	+13.1
Meat Packing	5,137	4,910	− 4.4	−22.5	147,073	161,772	+10.0	−21.8
Textiles								
Cotton Textile Mills	5,458	5,323	− 2.5	+ 4.2	138,160	133,605	− 3.3	+13.6
Men's Work Clothing	3,773	3,804	+ 0.8	−10.5	67,731	71,659	+ 5.8	− 4.5
Forest Products								
Furniture	1,110	1,075	− 3.1	− 3.9	35,512	34,465	− 2.9	+12.5
Planing Mills	1,678	1,674	− 0.2	− 7.2	55,784	55,880	+ 0.2	+ 7.1
Saw Mills	13,634	13,454	− 1.3	− 4.1	24,699	25,101	+ 1.6	+ 3.0
Paper Boxes	885	853	− 3.9	+11.1	21,580	20,046	− 7.1	+ 6.4
Printing and Publishing								
Commercial Printing	2,434	2,337	− 4.0	− 5.7	88,195	87,661	− 0.6	+ 1.9
Newspaper Publishing	3,895	3,944	+ 1.2	+ 2.3	123,177	127,980	+ 3.9	+14.0
Chemical Products								
Cotton Oil Mills	2,415	1,465	− 6.8	−37.8	47,446	20,248	−13.7	−48.4
Petroleum Refining	25,789	25,886	+ 0.4	+ 4.4	1,569,497	1,469,272	− 6.4	+ 4.6
Stone and Clay Products								
Brick and Tile	1,753	1,694	− 3.3	+10.9	32,371	32,719	+ 1.1	+24.0
Cement	717	715	− 0.3	−18.4	31,912	32,202	+ 0.9	− 1.7
Iron and Steel Products								
Structural and Ornamental Iron	2,447	2,511	+ 2.6	+ 2.3	86,600	85,577	− 1.2	+ 3.7
NONMANUFACTURING								
Crude Petroleum Production	28,415	28,935	+ 1.8	+ 6.4	1,609,007	1,637,941	+ 1.8	+13.8
Quarrying	(3)	(3)	− 1.4	+11.2	(3)	(3)	− 5.9	+16.2
Public Utilities	(3)	(3)	− 0.7	+ 0.1	(3)	(3)	− 1.2	+ 6.1
Retail Trade	207,022	207,818	+ 0.4	+ 0.3	5,330,561	5,308,615	− 0.4	−11.0
Wholesale Trade	61,890	61,406	− 0.8	− 0.6	2,618,728	2,534,398	− 3.2	+ 5.8
Dyeing and Cleaning	2,897	2,815	− 2.8	− 5.3	73,191	74,199	+ 1.4	+ 4.8
Hotels	19,557	19,424	− 0.7	− 0.7	368,448	365,166	− 0.9	+ 8.2
Power Laundries	13,902	13,579	− 2.3	− 6.4	263,380	254,915	− 3.2	+ 4.1

CHANGES IN EMPLOYMENT AND PAY ROLLS IN SELECTED CITIES[4]

	Employment Percentage Change		Pay Rolls Percentage Change			Employment Percentage Change		Pay Rolls Percentage Change	
	April, 1945 to May, 1945	May, 1944 to May, 1945	April, 1945 to May, 1945	May, 1944 to May, 1945		April, 1945 to May, 1945	May, 1944 to May, 1945	April, 1945 to May, 1945	May, 1944 to May, 1945
Abilene	+ 0.4	− 8.0	− 3.5	− 1.3	Galveston	− 10.5	− 18.8	− 10.2	− 13.1
Amarillo	+ 1.1	− 9.5	− 6.5	− 18.6	Houston	− 0.3	− 22.9	+ 4.2	− 17.8
Austin	− 4.7	+ 13.2	− 4.7	+ 14.9	Port Arthur	− 1.2	+ 3.3	− 6.4	+ 1.0
Beaumont	− 7.5	− 8.9	− 7.8	− 20.3	San Antonio	− 2.1	− 5.4	− 1.4	+ 7.0
Dallas	− 2.2	− 21.5	− 5.3	− 24.2	Sherman	+ 0.8	+ 10.6	+ 0.4	+ 38.9
El Paso	+ 1.7	+ 1.7	+ 0.9	+ 12.3	Waco	− 3.0	− 1.9	− 4.1	+ 7.2
Fort Worth	− 4.4	− 20.9	− 1.6	− 17.1	Wichita Falls	− 3.2	+ 0.2	− 8.2	+ 1.8
Corpus Christi	− 0.3	+ 8.8	− 2.2	+ 17.5	STATE	− 2.5	− 13.1	− 2.6	− 14.6

ESTIMATED NUMBER OF EMPLOYEES IN NONAGRICULTURAL BUSINESS AND GOVERNMENT ESTABLISHMENTS[6]

	1943[2]	1944[2]	1945		1943	1944
January	1,385,000	1,429,000	1,418,000[2]	July	1,450,000[1]	1,448,000[2]
February	1,397,000	1,433,000	1,413,000[2]	August	1,441,000[2]	1,446,000[2]
March	1,415,000	1,433,000	1,417,000[2]	September	1,448,000[2]	1,432,000[1]
April	1,433,000	1,435,000		October	1,455,000[2]	1,420,000[2]
May	1,458,000	1,435,000		November	1,461,000[2]	1,434,000[2]
June	1,478,000	1,448,000		December	1,470,000[2]	1,467,000[2]

*Does not include proprietors, firm members, officers of corporations, or other principal executives. Factory employment excludes also office, sales, technical and professional personnel.
†Does not include strictly war industries.
(1) Revised.
(2) Subject to revision.
(3) Not available.
(4) Based on unweighted figures.
(5) Less than 1/10 of one percent.
(6) Not including self-employed persons, casual workers, or domestic servants, and exclusive of military and maritime personnel. These figures are furnished by the Bureau of Labor Statistics, U.S. Department of Labor.

Prepared from reports from representative Texas establishments to the Bureau of Business Research co-operating with the Bureau of Labor Statistics.
Due to the national emergency, publication of data for certain industries is being withheld until further notice.

COTTON BALANCE SHEET FOR THE U. S. AS OF JUNE 1, 1945

(In Thousands of Running Bales Except as Noted)

Year	Carryover August 1	Imports to June 1**	Final Ginnings	Total	Cons. to June 1	Exports to June 1	Total	Balance June 1
1934–1935	7,746	94	9,472	17,312	4,586	4,174	8,760	8,552
1935–1936	7,138	122	10,417	17,677	5,189	5,519	10,708	6,969
1936–1937	5,397	198	12,130	17,725	6,680	5,086	11,766	5,959
1937–1938	4,498	119	18,242	22,859	4,856	5,227	10,083	12,776
1938–1939	11,533	122	11,621	23,276	5,758	3,107	8,866	14,410
1939–1940	13,033	137	11,477	24,647	6,591	5,931	12,522	12,125
1940–1941	10,596	150	12,287	23,033	7,619	976	8,595	14,438
1941–1942	12,367	—	10,489	22,856	9,218	—	9,208	13,648
1942–1943	10,590	—	12,437	23,027	9,342	—	9,342	13,685
1943–1944	10,687	80*	11,121	21,888	8,412	975*	9,387	12,501
1944–1945	10,727	106*	11,806	22,639	8,117	1,150*	9,267	13,372

The cotton year begins August 1.

**Figures are in 500-pound bales.

*Figures are to April 1, 1945 New York Cotton Exchange.

MAY RETAIL SALES OF INDEPENDENT STORES IN TEXAS

	Number of Establishments Reporting	Percentage Changes in Dollar Sales May, 1945 from May, 1944	May, 1945 from Aug., 1945	Year 1945 from Year 1944
TOTAL TEXAS	982	+ 4.2	+13.8	+ 9.9
STORES GROUPED BY LINE OF GOODS CARRIED:				
APPAREL	115	+ 4.7	+17.1	+11.6
Family Clothing Stores	25	+ 0.2	+17.8	+ 8.8
Men's and Boys' Clothing Stores	39	− 5.2	+21.5	+ 2.2
Shoe Stores	18	+ 0.3	+15.8	+13.9
Women's Specialty Shops	53	−16.1	+13.7	+17.5
AUTOMOTIVE*	85	−18.8	+ 8.6	− 7.1
Motor Vehicle Dealers	76	−22.7	+ 5.9	−10.6
COUNTRY GENERAL	93	− 1.7	+ 5.4	+ 3.6
DEPARTMENT STORES	61	+ 6.4	+16.9	+11.4
DRUG STORES	104	+ 8.0	+13.2	+ 7.7
DRY GOODS AND GENERAL MERCHANDISE	32	+ 8.3	+ 9.7	+15.3
FILLING STATIONS	27	+19.9	+24.7	+17.3
FLORISTS	22	+19.1	+48.0	+17.3
FOOD*	130	− 1.9	+ 6.8	+ 5.5
Grocery Stores	35	− 3.4	+ 6.9	+ 0.8
Grocery and Meat Stores	89	− 1.8	+ 7.2	+ 6.1
FURNITURE AND HOUSEHOLD*	78	+ 4.3	+ 7.3	+11.5
Furniture Stores	71	+ 5.0	+ 7.8	+11.8
JEWELRY	26	+20.1	+54.7	+ 3.8
LUMBER, BUILDING, AND HARDWARE*	166	+23.1	+ 8.4	+25.7
Farm Implement Dealers	18	+11.0	+23.3	+15.1
Hardware Stores	54	+11.6	+ 7.2	+17.6
Lumber and Building Material Dealers	92	+32.0	+ 9.1	+31.9
RESTAURANTS	28	+13.1	+ 4.4	+ 4.8
ALL OTHER STORES	11	+ 3.8	− 2.4	+ 4.3
TEXAS STORES GROUPED ACCORDING TO POPULATION OF CITY:				
All Stores in Cities of—				
Over 100,000 Population	153	+13.8	+16.4	+12.7
50,000–100,000 Population	118	− 7.6	+ 9.2	+ 6.4
2,500–50,000 Population	490	+ 4.6	+14.1	+ 7.6
Less than 2,500 Population	220	+ 4.0	+ 6.6	+ 8.9

*Group total includes kinds of business other than the classification listed.

Prepared from reports of independent retail stores to the Bureau of Business Research, coöperating with the U.S. Bureau of the Census.

DAIRY PRODUCTS MANUFACTURED IN PLANTS IN TEXAS

Product and Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
CREAMERY BUTTER (1000 lb.)													
1945*	1,546	1,786	2,492	3,612	4,250								
1944*	1,827	1,984	2,548	3,634	4,008	3,527	3,569	2,792	2,535	2,138	1,549	1,717	32,304
1930–39 average	2,074	2,109	2,392	3,138	3,556	3,166	4,113	2,867	2,513	2,608	2,301	2,211	33,048
ICE CREAM (1000 gal.)‡													
1945*	1,209	1,250	1,627	1,663	2,276								
1944*	991	1,075	1,332	1,516	2,491	2,944	3,200	2,997	2,193	1,897	1,680	1,076	24,011
1930–39 average	215	262	434	570	752	893	904	845	686	460	259	205	6,485
AMERICAN CHEESE (1000 lbs.)													
1945*	779	893	1,433	1,871	2,183								
1944*	762	919	1,306	1,886	2,273	2,159	2,076	1,621	1,372	1,148	869	708	17,197
1930–39 average	554	590	737	1,050	1,215	1,129	1,119	1,025	866	852	718	641	10,496
MILK EQUIVALENT OF DAIRY PRODUCTS† (1000 lbs.)													
1945*	57,308	63,892	90,817	123,244	148,240								
1944*	59,584	65,589	86,493	121,197	140,768	137,502	140,357	115,184	97,137	82,777	63,531	57,455	1,190,864
1930–39 average	54,675	57,139	67,456	89,641	104,323	97,562	97,075	89,185	76,165	73,444	60,119	55,872	922,656

*Estimates of production made by the Bureau of Business Research.

†Milk Equivalent of Dairy products was calculated from production data by the Bureau of Business Research.

‡Includes ice cream, sherbets, ices, etc.

NOTE: 10-year average production on creamery butter, ice cream and American cheese based on data from the Agricultural Marketing Service, U.S.D.A

MAY SHIPMENTS OF LIVE STOCK CKONVERTED TO A RAIL-CAR BASIS*

	Cattle		Calves		Hogs		Sheep		Total	
	1945	1944	1945	1944	1945	1944	1945	1944	1945	1944
Total Interstate Plus Fort Worth	8,137	6,287	953	840	663	1,741	3,242	2,738	12,995	11,605
Total Intrastate Omitting Fort Worth	1,121	946	139	212	9	98	153	135	1,422	1,391
TOTAL SHIPMENTS	9,258	7,232	1,092	1,052	672	1,839	3,395	2,873	14,417	12,996

TEXAS CAR-LOT* SHIPMENTS OF LIVE STOCK FOR YEAR 1943

	Cattle		Calves		Hogs		Sheep		Total	
	1945	1944	1945	1944	1945	1944	1945	1944	1945	1944
Total Interstate Plus Fort Worth	30,481	22,239	3,496	3,314	3,084	8,211	5,543	4,118	42,568	37,882
Total Intrastate Omitting Fort Worth	4,548	3,483	657	700	100	604	345	313	5,650	5,100
TOTAL SHIPMENTS	35,029	25,722	4,153	4,014	3,148	8,815	5,888	4,431	48,218	42,982

*Rail-car Basis: Cattle, 30 head per car; calves, 60; swine, 80; and sheep, 250.

Fort Worth shipments are combined with interstate forwardings in order that the bulk of market disappearance for the month may be shown.

NOTE: These data are furnished the United States Bureau of Agricultural Economics by railway officials through more than 1,500 station agents, representing every livestock shipping point in the State. The data are compiled by the Bureau of Business Research.

MAY CARLOAD MOVEMENT OF POULTRY AND EGGS

Shipments from Texas Stations

	Cars of Poultry						Cars of Eggs					
	Chickens		Turkeys		Shell		Frozen		Dried		Shell Equivalent†	
*Destination	1945	1944	1945	1944	1945	1944	1945	1944	1945	1944	1945	1944
TOTAL	7	41	22	17	92	194	118	124	62	128	826	1,466
Intrastate	2	12	11	8	31	88	54	51	—	25	139	390
Interstate	5	29	11	9	61	106	64	73	62	103	687	1,076

Receipts at Texas Stations

TOTAL	13	11	2	6	41	52	59	57	9	18	231	310
Intrastate	1	1	2	6	17	22	47	53	1	18	119	272
Interstate	12	10	0	0	24	30	12	4	8	0	112	38

*The destination above is the first destination as shown by the original waybill. Changes in destination brought about by diversion factors are not shown.

†Dried eggs and frozen eggs are converted to a shell-egg equivalent on the following basis: 1 rail carload of dried eggs=8 carloads of shell eggs, and 1 carload of frozen eggs=2 carloads of shell eggs.

NOTE: These data furnished to the Division of Agricultural Statistics, B.A.E., by railroad officials through agents at all stations which originate and receive carload shipments of poultry and eggs. The data are compiled by the Bureau of Business Research.

MAY CREDIT RATIOS IN TEXAS DEPARTMENT AND APPAREL STORES

(Expressed in Per Cent)

	Number of Stores Reporting	Ratio of Credit Sales to Net Sales 1945	Ratio of Credit Sales to Net Sales 1944	Ratio of Collections to Outstanding 1945	Ratio of Collections to Outstanding 1944	Ratio of Credit Salaries to Credit Sales 1945	Ratio of Credit Salaries to Credit Sales 1944
All Stores	60	46.1	44.1	72.2	71.9	1.1	1.1
Stores Grouped by Cities:							
Austin	7	51.8	38.4	72.3	75.7	1.3	1.4
Bryan	3	51.2	41.7	73.4	56.3	1.6	1.8
Dallas	8	55.7	53.7	64.6	63.5	0.8	0.8
El Paso	3	39.4	39.4	59.9	65.8	1.4	1.3
Fort Worth	5	41.5	39.1	68.9	68.3	1.2	1.1
Houston	8	42.5	41.6	65.9	66.3	1.4	1.4
San Antonio	3	37.9	36.9	66.7	66.6	1.1	1.2
Waco	5	44.4	43.5	64.4	67.9	1.3	1.2
All Others	8	39.9	40.2	72.2	71.9	1.0	0.9
Stores Grouped According to Type of Store:							
Department Stores (Annual Volume Over $500,000)	19	44.8	42.7	67.2	69.2	1.1	1.1
Department Stores (Annual Volume under $500,000)	10	38.1	39.5	67.0	64.5	1.3	1.4
Dry-Goods-Apparel Stores	3	38.4	36.8	69.5	70.9	1.7	1.8
Women's Specialty Shops	14	55.1	52.7	61.2	58.3	0.6	0.7
Men's Clothing Stores	14	43.3	42.7	70.7	67.2	1.3	1.2
Stores Grouped According to Volume of Net Sales During 1944:							
Over $2,500,000	18	48.3	45.8	65.3	65.5	1.0	1.0
$2,500,000 down to $1,000,000	11	41.1	40.9	71.6	72.3	0.9	0.8
$1,000,000 down to $500,000	12	34.0	35.8	66.5	64.8	0.9	0.9
Less than $500,000	19	33.4	34.7	71.6	70.3	1.7	1.9

NOTE: The ratios shown for each year, in the order in which they appear from left to right are obtained by the following computations: (1) Credit Sales divided by Net Sales. (2) Collections during the month divided by the total accounts unpaid on the first of the month. (3) Salaries of the credit department divided by credit sales. The data are reported to the Bureau of Business Research by Texas retail stores.

TEXAS CHARTERS

	May, 1945	May, 1944	April, 1945
Domestic Corporations:			
Capitalization*	$1,220	$768	$880
Number	77	50	79
Classification of new corporations:			
Banking-Finance	5	1	3
Manufacturing	8	3	15
Merchandising	25	20	16
Oil	9	2	4
Public Service	4	0	29
Real Estate Building	8	4	6
Transportation	6	0	4
All Others	12	20	2
Number capitalized at less than $5,000	26	12	27
Number capitalized at $100,000 or more	3	4	2
Foreign Corporations (Number)	25	10	29

*In thousands.
NOTE: Compiled from records of the Secretary of State.

TEXAS COMMERCIAL FAILURES

	May, 1945	May, 1944	April, 1945
Number	1	0	0
Liabilities*	$2.2	0	0
Assets*	$2.0	0	0
Average Liabilities per Failure*	$2.2	0	0

*In thousands.
NOTE: From Dun and Bradstreet Inc.

COMMODITY PRICES

	May, 1945	May, 1944	April, 1945
Wholesale Prices:			
U. S. Bureau of Labor Statistics (1926=100)	106.0	104.0	105.7
Farm Prices:			
U. S. Bureau of Labor Statistics (1926=100)	129.9	122.9	129.0
Retail Prices:			
Food (U. S. Bureau of Labor Statistics (1935–1939=100)	138.8	135.5	136.6
Cost of Living Index (1935–1939 =100)	128.0	125.0	127.1
Department Stores (Fairchild's Publications January, 1931=100)	113.4	113.4	113.4

CEMENT

(In Thousands of Barrels)

	April, 1945	April, 1944	March, 1945
Texas Plants			
Production	566	575	576
Shipments	572	622	598
Stocks	991	984	997
United States			
Production	7,084	6,463	6,398
Shipments	7,894	7,373	6,988
Stocks	20,778	24,085	21,581
Capacity Operated	36.0%	32.0%	31.0%

NOTE: From U.S. Department of Interior, Bureau of Mines.

POSTAL RECEIPTS

	May, 1945	May, 1944	April, 1945
Abilene	$ 29,968	$ 47,392	$ 33,063
Amarillo	62,769	56,042	59,106
Austin	108,002	102,044	107,452
Beaumont	52,443	49,325	49,871
Big Spring	12,792	10,685	14,165
Brownsville	12,259	12,137	12,956
Brownwood	19,930	77,598	19,784
Childress	8,084	5,477	7,170
Cleburne	6,671	5,702	6,829
Coleman	4,225	3,966	4,934
Corpus Christi	79,392	70,325	72,744
Corsicana	9,935	9,718	10,679
Dallas	580,720	549,032	576,083
Del Rio	7,004	6,527	7,844
Denison	10,959	11,191	10,979
Denton	14,376	12,066	14,031
Edinburg	4,744	4,519	5,246
El Paso	91,237	105,503	94,761
Fort Worth	269,160	238,508	249,501
Galveston	50,895	53,351	53,873
Gladewater	3,967	3,836	4,893
Graham	3,849	3,410	3,808
Harlingen	18,180	13,764	15,908
Houston	434,379	399,251	400,693
Jacksonville	6,268	6,530	6,388
Kenedy	2,063	2,766	2,464
Kerrville	4,216	3,904	4,675
Longview	16,233	14,806	15,218
Lubbock	32,473	32,669	34,508
Lufkin	9,523	8,422	7,926
McAllen	8,377	7,078	8,760
Marshall	13,146	10,701	11,531
Midland	16,280	12,893	15,185
Palestine	8,883	8,249	8,302
Pampa	11,492	1,537	10,591
Paris	21,798	22,297	22,204
Plainview	6,464	6,180	6,649
Port Arthur	30,172	28,937	28,577
San Angelo	26,928	22,638	26,928
San Antonio	272,485	274,400	256,764
Seguin	4,449	4,076	3,811
Sherman	14,838	12,265	14,442
Snyder	2,376	2,602	2,655
Sweetwater	10,564	8,767	9,847
Temple	17,005	14,621	17,298
Texarkana	27,962	28,736	28,545
Tyler	31,475	31,081	29,754
Waco	58,515	54,551	61,428
Wichita Falls	52,762	44,021	49,572
TOTAL	$2,602,687	$2,405,796	$2,507,439

Note: Compiled from reports from Texas chambers of commerce to the Bureau of Business Research.

PERCENTAGE CHANGES IN CONSUMPTION OF ELECTRIC POWER

	May, 1945 from May, 1944	May, 1945 from April, 1945
Commercial	+12.4	− 0.6
Industrial	+14.4	+ 5.6
Residential	+14.3	+ 0.9
All Others	+ 2.5	+ 5.6
TOTAL	+11.9	+11.9

Prepared from reports of 10 electric power companies to the Bureau of Business Research.

BUILDING PERMITS

	May, 1945	May, 1944	April, 1945
Abilene	$ 16,885	$ 13,460	$ 19,650
Amarillo	422,599	124,035	104,187
Austin	140,541	45,448	135,773
Beaumont	70,104	41,450	85,927
Big Spring	33,880	28,025	97,410
Brownsville	29,709	33,117	9,400
Corpus Christi	509,056	115,553	205,339
Dallas	876,099	1,490,192	644,912
Denison	21,917	5,515	12,934
Denton	18,150	1,050	5,360
Edinburg	1,030	625	12,560
El Paso	133,273	226,599	49,338
Fort Worth	763,284	402,929	543,999
Galveston	60,025	128,019	53,652
Gladewater	950	1,050	1,125
Graham	16,700	300	2,870
Harlingen	28,470	12,650	13,650
Houston	4,644,291	804,107	1,111,961
Jacksonville	15,800	800	3,300
Kenedy	0	550	5,500
Kerrville	17,890	1,075	24,550
Longview	11,260	3,075	5,050
Lubbock	157,881	81,648	133,337
McAllen	17,000	10,275	59,005
Marshall	15,984	12,076	11,034
Midland	97,500	3,701	61,650
Palestine	3,634	1,960	15,175
Pampa	15,000	1,765	50,600
Paris	31,137	10,260	15,050
Plainview	13,035	5,200	15,325
Port Arthur	62,299	25,433	66,607
San Antonio	478,697	312,099	433,361
Seguin	14,200	1,189	1,100
Sherman	23,564	14,891	55,884
Snyder	2,000	0	2,500
Sweetwater	12,945	71,135	8,545
Tyler	59,975	18,010	57,336
Waco	420,500	258,972	57,840
Wichita Falls	135,339	9,590	23,403
TOTAL	$9,392,603	$4,272,380	$4,216,199

Note: Compiled from reports from Texas chambers of commerce to the Bureau of Business Research.

LUMBER

(In Board Feet)

	May, 1945	May, 1944	April, 1945
Southern Pine Mills:			
Average Weekly Production per unit	204,042	196,811	202,454
Average Weekly Shipments per unit	217,402	205,926	208,063
Average Unfilled Orders per unit, end of month	1,448,640	1,558,546	1,617,697

Note: From Southern Pine Association.

MAY RETAIL SALES OF INDEPENDENT STORES IN TEXAS

(By Districts)

	Number of Establishments Reporting	Percentage Changes May, 1945 from May, 1944	May, 1945 from April, 1945	Year 1945 from Year 1944
TOTAL TEXAS	982	+ 4.2	+13.8	+ 9.9
TEXAS STORES GROUPED BY PRODUCING AREAS				
District 1–N	63	−30.3	+ 6.4	− 0.4
Amarillo	22	−50.4	− 0.9	
Plainview	12	+20.7	+23.9	
All Others	29	+14.2	+12.5	
District 1–S	26	+15.2	+16.6	+13.6
Lubbock	13	+14.3	+17.4	
All Others	13	+17.5	+14.9	
District 2	87	+ 7.5	+15.9	+11.8
Abilene	20	− 6.9	+12.6	
All Others	67	+13.2	+17.1	
District 3	35	+ 6.9	+15.2	+12.3
District 4	233	+ 7.2	+15.7	+11.2
Dallas	32	+11.1	+17.3	
Fort Worth	35	+ 5.2	+14.3	
Waco	25	+ 4.2	+23.0	
All Others	141	*	+10.1	
District 5	117	+ 6.9	+11.2	+ 9.1
District 6	28	+ 4.5	+ 9.0	+ 9.6
District 7	52	+ 5.2	+14.2	+ 5.6
District 8	164	+ 6.8	+11.7	+12.7
Austin	16	− 1.5	− 4.6	
Corpus Christi	20	+ 8.9	+10.9	
San Antonio	44	+13.8	+16.3	
All Others	84	+ 0.6	+13.1	
District 9	105	+ 2.7	+14.6	+ 7.3
Beaumont	14	− 2.7	+14.3	
Houston	42	+ 5.3	+16.6	
All Others	49	− 1.8	+ 7.9	
District 10	28	+ 5.3	+15.8	+ 6.8
District 10A	44	+ 1.1	+12.0	− 1.0

*Change of less than .5%

NOTE: Prepared from reports of independent retail stores to the Bureau of Business Research, coöperating with the U.S. Bureau of the Census.

PETROLEUM

Daily Average Production (In Barrels)

	May, 1945	May, 1944	April, 1945
Coastal Texas*	563,300	519,800	565,250
East Central Texas	138,200	137,100	138,550
East Texas	379,800	364,100	378,100
North Texas	153,900	147,200	150,000
Panhandle	90,000	91,000	90,000
Southwest Texas	355,650	307,100	352,150
West Texas	495,300	429,100	489,500
STATE	2,176,150	1,995,400	2,163,550
UNITED STATES	4,866,765	4,512,000	4,804,815

Gasoline sales as indicated by taxes collected by the State Comptroller were: April, 1945, 111,287,216 gallons; April, 1944, 108,901,194 gallons; March, 1945, 117,838,065 gallons.

April sales to the United States Government as recorded by motor fuel distributors in Texas were 335,124,775 gallons.

*Includes Conroe.

NOTE: From American Petroleum Institute. See accompanying map showing the oil producing districts of Texas.

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